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Summer range ecology of white-tailed deer in the coniferous forests of northwestern Montana

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SUMMER RANGE ECOLOGY OF WHITE-TAILED DEER IN THE CONIFEROUS FORESTS OF NORTHWESTERN MONTANA

By

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ABSTRACT

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Summer Range Ecology of White-tailed Deer in the Coniferous Forests of Northwestern Montana (80 pp.)

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During 1980 and 1981, I studied the ecology of white-tailed deer (Odocoileus virginianus) on the Swan-Clearwater summer range, northwestern Montana. Summer home ranges were well dispersed over the study area. Deer monitored both summers established their ranges in the same areas each year. Average home range size was 71 ha for adults and 91 ha for yearlings. Three deer followed for 24-hour periods confined movements inside or near to home ranges delineated during daytime tracking. Adult home ranges contained significantly more riparian and unlogged upland habitats, and significantly less logged upland than expected. Habitat composition within home ranges of yearlings more closely paralleled composition on the entire study area, except yearlings had significantly more logged riparian habitat than expected. Yearling ranges were composed largely of marginal (logged) habitats, most commonly logged riparian habitat with abundant deciduous cover, remnant conifers, and high diversity. Deer ranges also contained significantly more cool site and riparian habitat types and topographic features, mature subclimax coniferous forest, and diversity than expected. Adults and yearlings selected similar habitats within home ranges. Both used riparian habitats, both unlogged and logged, significantly more than expected, and upland habitats, both unlogged and logged, significantly less than expected. Management implications included: 1) protect riparian areas from logging; 2) retain unlogged coniferous forest around riparian areas; 3) plan cutting units as small (< 12 ha) and as scattered as possible (≤ 5 per section); and 4) plan additional entries only after second growth in logged units is sufficiently developed to provide hiding cover.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The white-tailed deer (Odocoileus virginianus) is the most important big game species in northwestern Montana, where it is closely associated with coniferous forest habitat (Mackie et al. 1979). Studies there indicated reduced deer harvests and increased hunting pressure, concurrent with increased timber harvests (Weckwerth 1958, Hildebrand 1971, Mundinger 1979). These investigations focused on winter ecology of deer in the Swan Valley; summer range ecology, however, was not fully studied.

Mackie (1978) and Mackie et al. (1979) proposed that population regulation in deer must be viewed from a perspective in which the relevant habitat is the total environment that deer occupy yearlong. In this perspective, spring-summer-fall ranges may be equally as important or more important than winter ranges in their influence on population dynamics.

Other workers have discussed aspects of white-tailed deer summer range such as restricted size and affinity for certain areas [Townsend and Smith 1933 (New York), Dahlberg and Guettinger 1956, McCaffery and Creed 1969 (Wisconsin), Hawkins and Klimstra 1970 (Illinois), Verme 1973 (Michigan), Inglis et al. 1979 (Texas), Nelson 1979, Nelson and Mech 1981 (Minnesota)], and summer habitat use

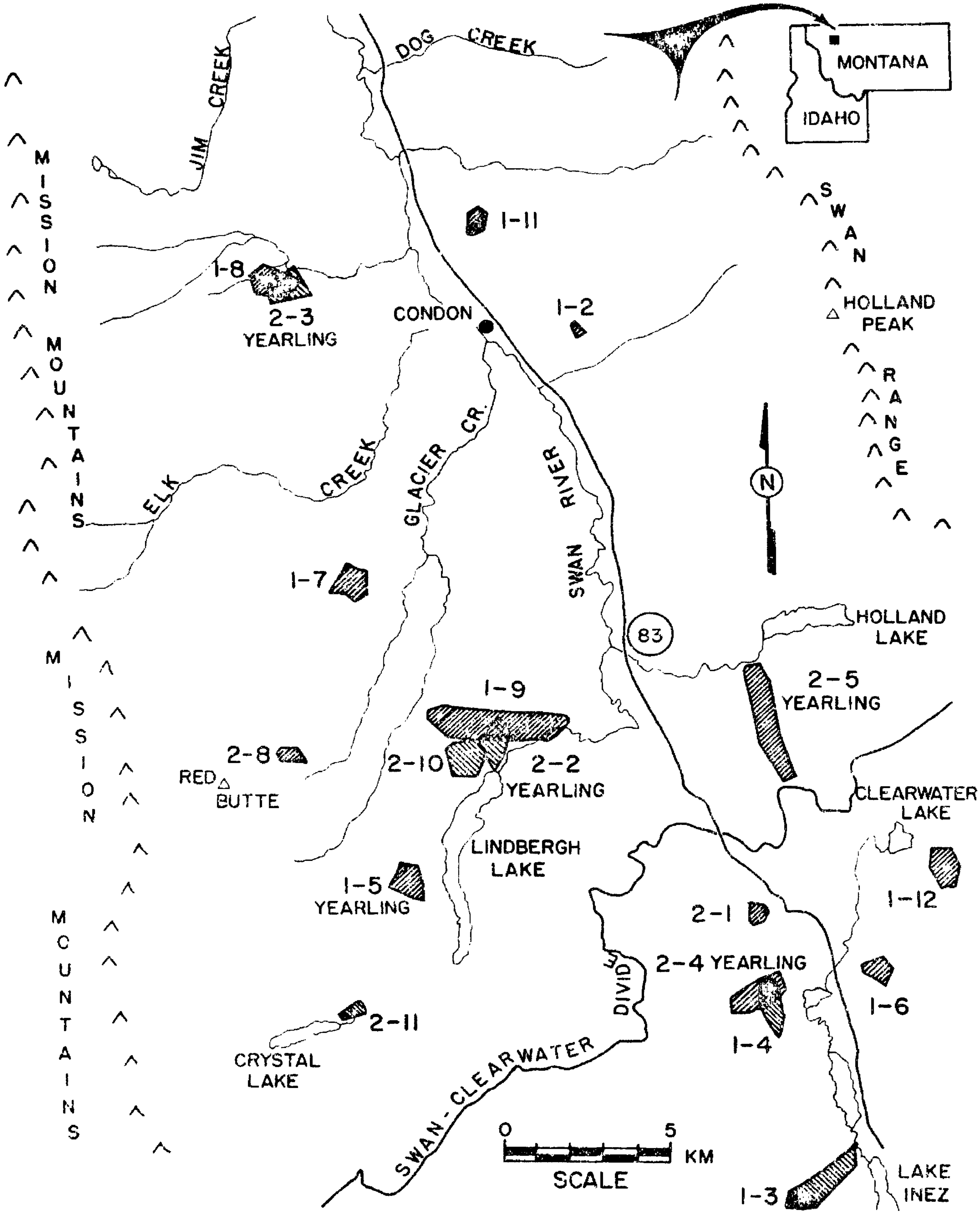
[Allen 1968 (central Montana), Martinka 1968 (north-central Montana), Kohn and Mooty 1971 (Minnesota), Drolet 1976 (New Brunswick)]. None, however, focused on white-tailed deer and habitat relationships in coniferous forests of the mountainous northwest.

During summer 1980, I began a study of the summer range ecology of white-tailed deer in the Swan River Valley, Montana. Objectives were to: 1) identify and describe summer habitat of white-tailed deer; 2) determine ecological relationships between deer and habitat components; and 3) evaluate possible influences of fire and logging on summer habitat relationships.

Study Area

The study area includes the southern half of the Swan Valley and the northern quarter of the adjacent Clearwater Valley (Fig. 1). The 2 valleys occupy a north-south trench, bounded by mountains on each side. The study area is approximately 45 km long and 15 km wide, extending from Dog Creek south to Lake Inez, and spreading east and west to the foothills of the Swan and Mission Mountains. Highway 83 transects the length of the study area. The north-flowing Swan River and the south-flowing Clearwater run parallel to and often adjacent to the highway. Elevations in the area range from 1060 m on the Swan Valley floor and 1229 m at Lake Inez to 1575 m on the mid-slopes of the mountains. The Swan-Clearwater Divide varies between

e study area.



, area, including summer home ranges of deer.

Several authors have described the Swan Valley (Hildebrand 1971, Antos 1977, Antos and Habeck 1981, Mundinger 1981) and the northern Clearwater (Freedman 1980) in detail. The study area is near the eastern edge of low elevation, wet coniferous forests influenced by moist Pacific air masses (Antos and Habeck 1981). The entire area was glaciated, contributing to broken topography, variable soil moisture regimes, and numerous inclusions of microhabitats (Marcum pers. comm.). The 2 valleys of the study area are similar and I will refer to them as the Swan-Clearwater summer range.

METHODS AND MATERIALS

Trapping

Deer were captured and radio-collared on the upper Swan Valley winter range (Goat Creek south to Dog Creek) in 1977-78, 1978-79, and 1980-81. Single-gate deer traps (Clover 1956) were baited with alfalfa hay and checked daily. Age, sex, and condition of captured deer were recorded, and a metal ear tag was placed in each ear. Suitable deer, healthy does between $1\frac{1}{2}$ and $5\frac{1}{2}$ years of age, were radio-collared. Several fawns were collared during 1980-81 because poor trapping success of adults occurred that winter. Collars consisted of a radio package attached to 5-cm wide belting and weighed approximately 500 gm. Frequencies ranged from 150.725 to 151.225 MHz.

Delineation of Summer Home Ranges

I monitored 18 white-tailed deer by telemetry. Deer were located by ground tracking with a hand-held telonics "H" antenna, and an AVM model LA-12 receiver. Several tracking flights were also made each year.

A reliable ground fix included one of the following: 1) triangulation with 2 or 3 compass bearings from known points on a trail or road to the deer; 2) disturbance of the animal; 3) lengthy tracking of the animal to determine its starting position and course of evasion. Extensive road and trail systems provided access to the general vicinity of the animals. From there, I followed game trails in the direction of peak signal strength. Often, I was able to closely approach the animal before it was sufficiently disturbed to move. Thereafter, movement was indicated by changes in signal strength and direction. That information, in relation to habitat and topographic features, was used to determine the animal's origin and movement pattern.

Deer locations were recorded on 1:15,840 topographic maps and aerial photographs. Home ranges were delineated by connecting the outermost points to form a convex polygon (Mohr 1947). Thirty-four different summer home ranges were delineated: 10 home ranges of adults in 1980, 11 adult ranges and 5 yearling ranges in 1981, and 8 composite home ranges for adults tracked both summers. Eight matched pairs of home range sizes for deer followed both years were compared with a Wilcoxon signed rank test to determine if deer had similar home range sizes in 1980 and 1981. Also, home range sizes of 11 adults tracked in 1981 were compared (Mann-Whitney test) to home range sizes of 5 yearlings tracked that year to detect differences in summer home range size between the 2 age groups.

Home ranges were analyzed for percent size increase with additional locations (Odum and Kuenzler 1955) to determine if the number of locations was sufficient. For each home range examined, a series of 4 to 6 polygons was constructed. The first polygon included the first half of the locations, and succeeding polygons included the next 2 or 3 locations. If a 1% or less increase occurred for each additional observation (or 2% increase for 2 observations), data were considered sufficient to indicate actual home range size. For deer with 2 years of data, composite ranges were analyzed by designating the last location of 1980 to be followed by the first location of 1981. Composite analysis was possible because these deer used the same home range vicinity both years.

I attempted to locate each deer at least twice each week during 1980. Also, 3 deer were followed, each for a 24-hour period, to establish circadian activity in relation to delineated home range. In 1981, I emphasized relocating the 8 deer collared the preceding winter, and attempted to locate each 15-20 times.

Habitat Category Availability

Twenty-six home ranges for 18 individual deer were described according to 4 broad habitat categories: unlogged upland, logged upland, unlogged riparian, and logged riparian. Ranges of 8 adults tracked both years were described separately for each year because this analysis was the most sensitive for habitat selection. If composite ranges were used, the convex polygon inflated the availability of some habitat categories, and masked habitat selection within the home range. Although the home range vicinity did not change between years, habitat selection within home ranges could differ, and these preferences would be hidden by composite home range analyses.

Habitat Selection

Deer relocations (use) in the 4 habitat categories were compared to habitat category availability to determine habitat selection. I tested the null hypothesis that a deer used each habitat category in proportion to its occurrence within the home range, using a chi-square goodness-of-fit test (Neu et al. 1974). If rejected, 90% simultaneous (97.5% individual) confidence intervals were calculated to determine if a deer used each category more or less than expected, based on proportionate availability (or more or less than expected, Neu et al. 1974). I also analyzed selection by age group on 21 adult and 5 yearling ranges.

Description of Summer Home Ranges and Random Areas

Delineation of Random Areas. To compare summer home ranges with unsampled portions of the study area, I selected and visited 15 "random areas." These simulated the size, shape, and elevation of the "average" of the 10 summer home ranges delineated in 1980. I constructed a grid of the study area and determined the coordinates of the geometric center for each area with random numbers. The selected area had to be habitat available for deer (i.e., not in the middle of a lake), and below 1515 m elevation. Twenty-nine areas were reviewed, and the first 15 to meet the criteria were selected as random areas.

The average size of 15 random areas measured 45 ha. This was less than the planned figure, the average size of 10 summer home ranges delineated in 1980 (70 ha), because of errors I made in home range delineation. Two very mobile deer seemed to split their summer home ranges into 2 use areas separated by a long corridor where no relocations were recorded. Consequently, I initially estimated their home range sizes by adding the measurements of the 2 concentration areas without including the area between. This error contributed to my underestimating the average home range size in 1980 as only 51 ha. Nevertheless, the random areas at least estimate proportions of habitat availability within the Swan-Clearwater summer range, and they were included in subsequent analyses.

Description of Habitat on Summer Home Ranges and Random Areas. Each summer home range and random area was mapped according to habitat category, Habitat Type (H. T., Pfister et al. 1977), topographic feature, cover-successional type, and vertical vegetative cover. To delineate mapping units, aerial photographs and topographic maps were studied for differences in slope, exposure, topography, and cover type.

Mapping was difficult because microsite inclusions and diversity were typical. Mapping units often contained several H.T. s. Thus, I described each as a mosaic of H.T. s, and estimated the coverage of each.

Topographic features included the following: N-NE-E, E-SE-S, S-SW-W, and W-NW-N slopes; dry benches; wet benches; flats; undulating; main streams; small creeks; potholes; and avalanche chutes.

On upland sites, the cover-successional types included: shrub-seedling-sapling; pole lodgepole; open canopy lodgepole; mature seral, mixed species; old-growth, climax species dominant; and selection cut. These categories included all the various cover types that I encountered.

Vertical vegetative cover was estimated with a cover-density board (Nudds 1977). The board was 2 m high, 1 dm wide, and marked at 1 dm intervals. An assistant held the board 20 m from the observer, who read the percentage of the board visible. Two opposing readings were taken from a common point, randomly selected in each mapping unit.

To detect possible habitat patterns on deer summer home ranges, I designated community types--unique combinations of H.T., topographic feature, and cover-successional type--and counted the number of deer summer home ranges that contained similar community types.

A diversity index was calculated for deer summer home ranges and random areas by adding the number of discrete H.T.s and riparian units and dividing by the area of the home range or random area.

Comparison Between Summer Home Ranges and Random Areas

To compare the composition of deer summer home ranges with random areas, I used statistical analysis similar to that described by Marcum and Loftsgaarden (1980). This required selecting points within deer home ranges by dot grid to estimate habitat composition with discrete data. I tested the hypotheses that the proportion of each habitat parameter in deer summer home ranges equaled the proportion in the random areas. If rejected, confidence intervals were calculated to determine if deer home ranges contained each parameter more or less than expected from availability on random areas (Neu et al. 1974). Probability levels for simultaneous confidence intervals were reported for comparisons of topographic features and cover-successional types.

Mapping units and H.T.s were compared descriptively. Mean vertical vegetative cover board readings were compared (Kruskal-Wallis). Diversity indices were ranked and compared (Mann-Whitney) to determine if deer ranges and random areas were similar with respect to diversity rank.

In all comparisons except those of the 4 habitat categories, data from 3 deer (2 adults and 1 yearling) were deleted because I had mapped their ranges as 2 discrete concentration areas without including the corridors between. Also, in these analyses, data from composite ranges were used for adults tracked both summers.

RESULTS

During summer 1980, I collected telemetry data from 4 adult does captured during winter 1977-78 and 6 adults trapped in 1978-79. Eight of these 10, and 8 newly collared does (3 adults and 5 yearlings), were followed in 1981 (Appendix I).

Distribution of Summer Home Ranges

Summer ranges for 18 individuals were well dispersed over the study area (Fig. 1). Three pairs of telemetered deer had overlapping ranges. One yearling and her dam (#2-4 and 1-4) were located together, within the dam's home range, until late June. Then the yearling shifted her home range adjacent to her dam's. Another yearling (2-3) occupied a range adjacent to that of her dam (a doe with a nonfunctional radio).

The other pairs with overlapping ranges each consisted of an adult and a nonrelated yearling. I observed both adults with their unmarked fawns, and both yearlings with their apparent dams. In 1 pair (2-2 and 1-9), the yearling used an unused portion of the adult's range. The yearling made 1 excursion 2 km from her home range sometime between 10 and 22 June. The other pair (2-3 and 1-8) shared a common area, but used it at different times. I never located them closer to each other than 200 m. The yearling moved 24 km from her home range sometime between 21 and 31 July, the only other trip from a delineated home range that I observed.

The remaining 2 telemetered yearlings made erratic movements. One (1-5) was located 7 times from 12 March to 2 May on her presumed dam's home range. During that period, she made 1 excursion to an unknown place. By 15 May she had moved 15 km to her subsequent home range. Thereafter, she was apparently solitary. The other yearling (2-5) shifted use between 2 core areas separated by 3 km. I located her 7 times at the presumed dam's summer range, often in a group of 3 deer. She was located 13 times at her second area, and was usually solitary. I detected 8 shifts between the 2 areas from 20 May to 20 July, with 2-12 days between movements. After 20 July she was always located at the second area.

Fidelity to Summer Home Range

The home ranges of 8 deer monitored in 1980 and 1981 overlapped 44% between summers. Core areas of use were the same. Those ranges also were similar to the respective areas used in 1979 (Mundinger pers. comm.). Locations of yearling 2-3 also demonstrated this tendency for fidelity to established seasonal home ranges. She was captured at the same trap site where her dam (a doe with a nonfunctional radio) had been captured in winter 1977-78. These deer were together twice before 6 May 1981 within the home range previously delineated for the adult (Mundinger pers. comm.). Thereafter, the yearling occupied an area adjacent to that of her dam.

Summer Home Range Size

Locations were sufficient (Odum and Kuenzler 1955) to delineate summer ranges for 12 of 21 adults and 3 of 5 yearlings (Table 1). For 8 deer with 2-year composite ranges, analyses indicated enough locations for 6 deer. All home ranges were included in analyses of habitat selection because the size variation with additional relocations was approaching 1% (Figs. 2-4).

Table 1. Relocations and home range sizes.

	Deer	Number of Locations	Size (ha)	Composite Range
Adults				
			1980	
	1-9	19	289*	
	2-10	32	55*	
	2-8	9	30*	
	1-3	15	110	
	1-11	36	19*	
	1-2	33	10*	
	2-1	20	37*	
	1-6	15	31	
	2-11	13	36	
	1-7	22	87	
		Total = 214	$\bar{x}$ = 70.4 ± 26.2 s.e.	
			1981	
	1-9	18	222	404*
	2-10	22	38*	69*
	2-8	12	18	41*
	1-3	11	75*	154*
	1-11	16	27*	31*
	1-2	13	12	15
	2-1	19	54*	72*
	1-6	16	43	55
	1-8	24	97*	
	1-12	25	131*	$\bar{x}$ = 105.1 ± 45.2 s.e.
	1-4	18	62	
		Total = 194	$\bar{x}$ = 70.8 ± 18.5 s.e.	
Yearlings				
	1-5	23	34*	
	2-3	19	61*	
	2-2	24	89	
	2-5	20	208	
	2-4	21	64*	
		Total = 107	$\bar{x}$ = 91.2 ± 30.4 s.e.	

*Locations sufficient to delineate home range.

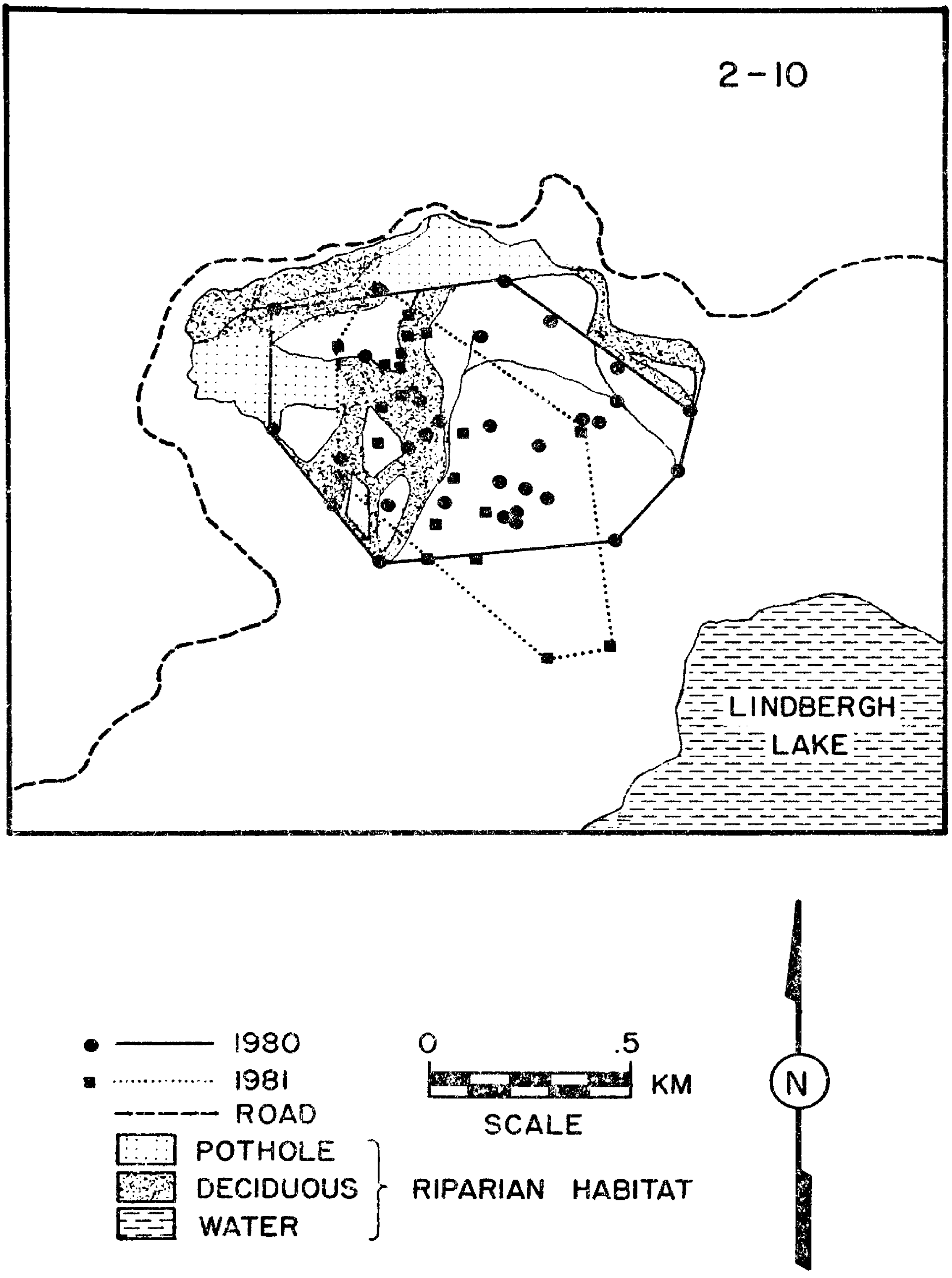


Fig. 2. Home ranges of an adult during 1980 and 1981.

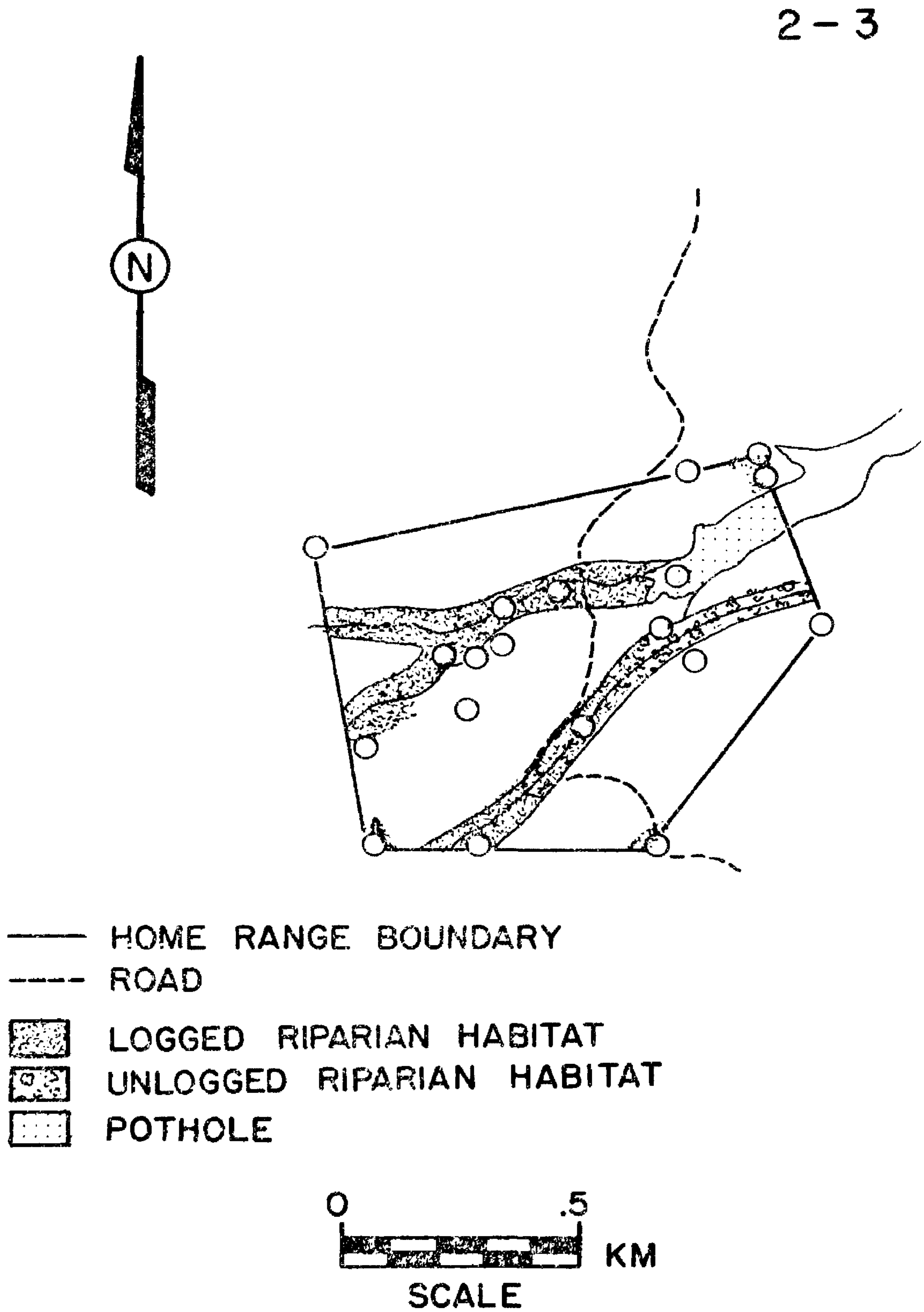


Fig. 3. Home range of a yearling, established in predominantly logged habitat.

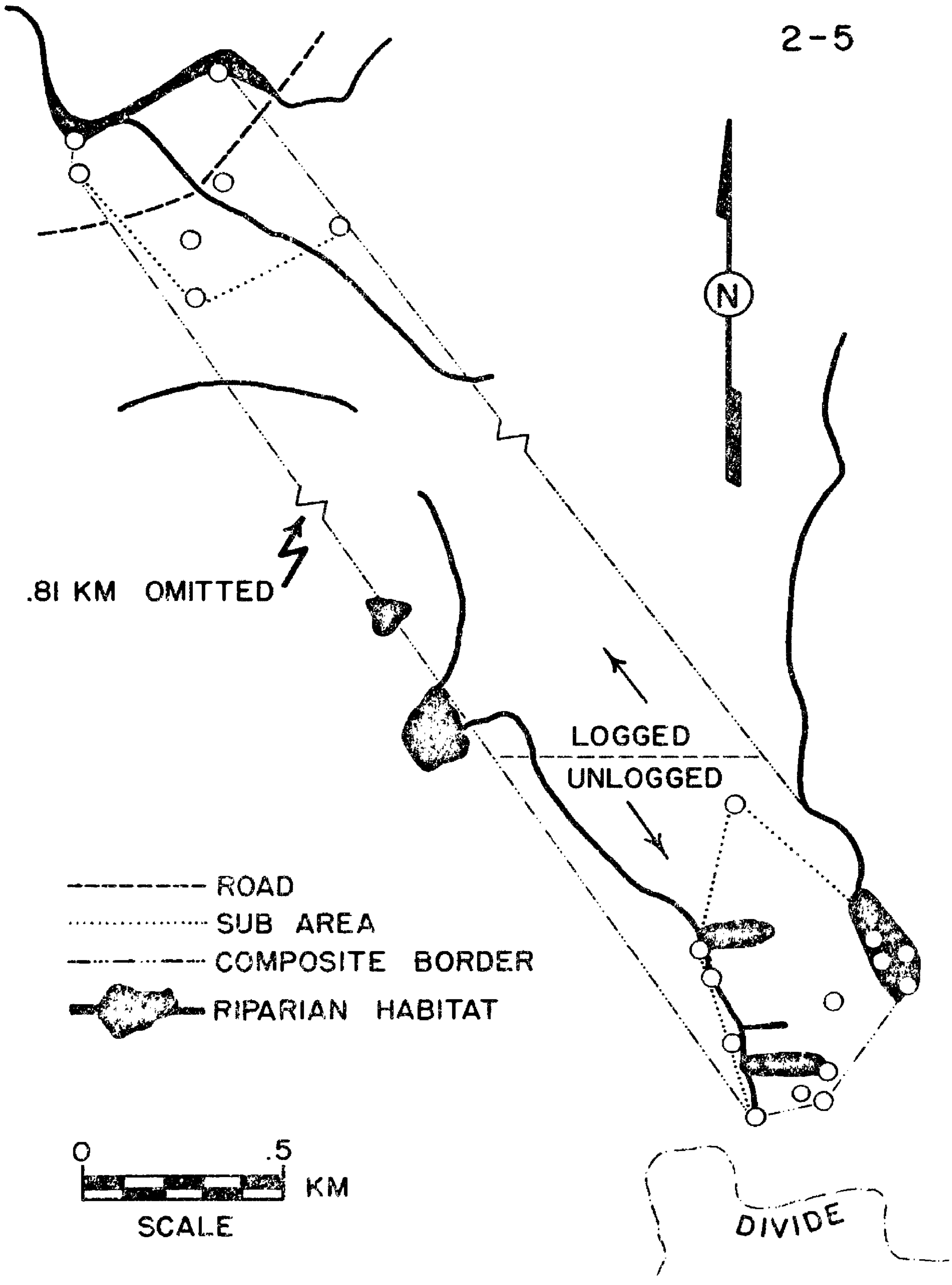


Fig. 4. Home range of a yearling, composed of 2 core areas separated by 3 km.

The average summer home range size of adults was 71 ha. Average sizes were similar between years (73 ha in 1980 and 61 ha in 1981, Wilcoxon $P = 0.4592$) for the 8 deer followed both summers. The average home range size of 5 yearlings was 91 ha (Table 1). Although larger than that of 11 adults followed that year ($\bar{x} = 71$ ha), the difference was not significant (Mann-Whitney $P = 0.25$).

Three deer were monitored, each for a 24-hour period in 1980. Of 46 locations, 3 occurred outside the summer home ranges previously defined for 2 deer. All 3 locations were close to indicated boundaries and each increased the home range size less than 7%.

Habitat Selection

Adult summer home ranges contained 4 habitat categories in the following proportions: 64% unlogged upland; 21% logged upland; 12% unlogged riparian; and 3% logged riparian (Appendix II). Summer ranges of 2 adults contained no logged habitat; ranges of 2 others contained no logged riparian habitat.

Composition of yearling ranges included: 36% unlogged upland; 50% logged upland; 7% unlogged riparian; and 7% logged riparian (Appendix II).

Collectively, selection by adults and yearlings was similar, and use differed significantly from availability in all 4 habitat categories ($P < 0.10$, Fig. 5). For both age-groups, I found animals more frequently

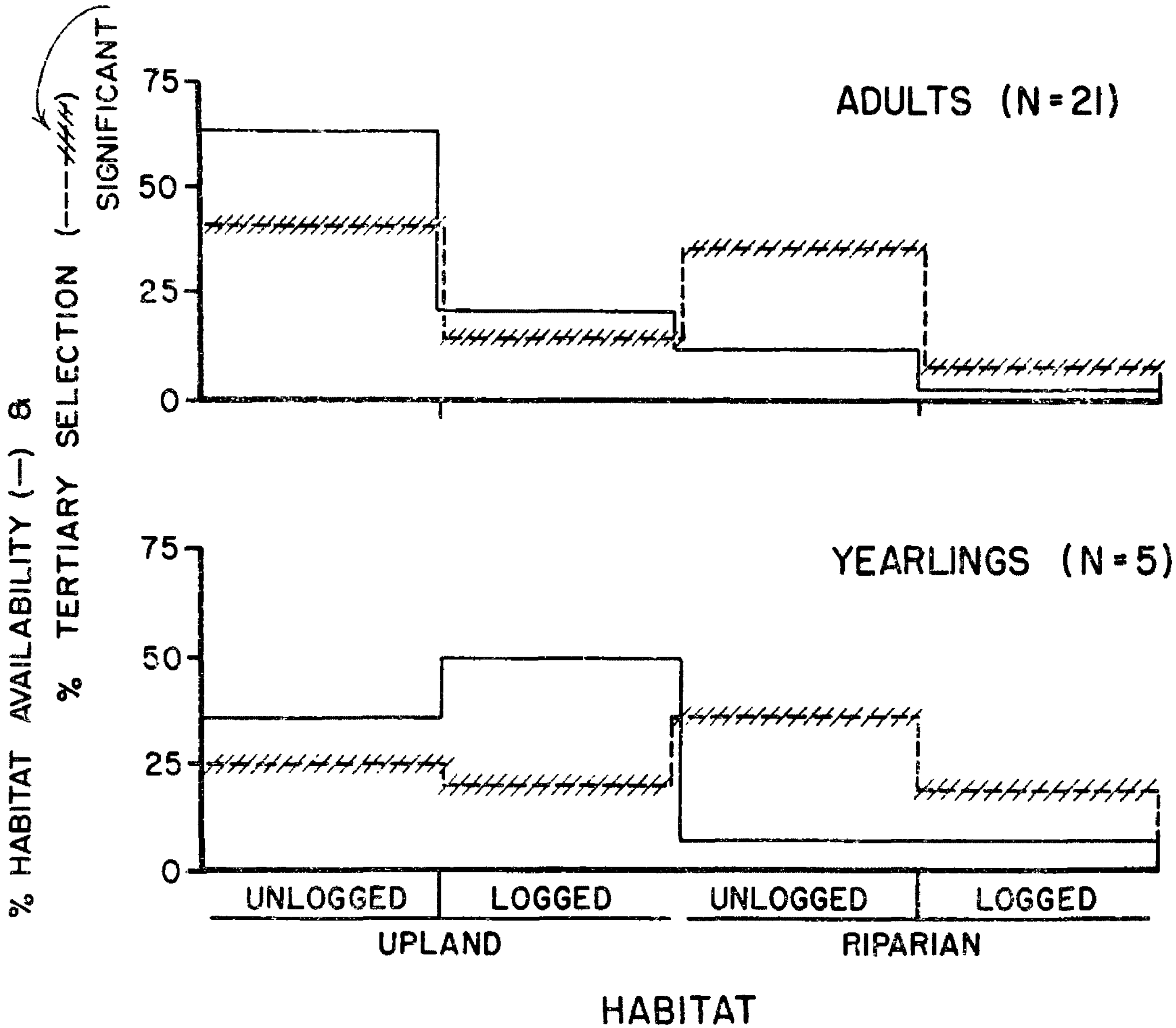


Fig. 5. Habitat selection within deer home ranges (tertiary selection, Johnson 1980, 90% simultaneous confidence intervals).

than expected in riparian habitats and less frequently than expected in upland habitats.

Habitat use by individuals was consistent with the pooled data. Thirteen deer used at least 1 riparian habitat more than expected. No deer used riparian habitats less than expected. Unlogged riparian habitat occurred in trace amounts on the home ranges of 2 deer (1-8 and 2-3). These 2 used logged riparian habitat more than expected. That habitat had residual conifers and dense cover of birch (Betula papyrifera), alder (Alnus sinuata), dogwood (Cornus stolonifera), and willows (Salix spp.). Twelve deer used at least 1 upland habitat less than expected, and no deer used upland habitats more than expected (Appendix II). Several deer changed use between summers from significantly more or less than expected to not significantly different. Among these deer, shifts in habitat selection between years were not consistent (Table 2).

Comparison Between Summer Home Ranges and Random Areas

Habitat Category. Fifteen random areas contained habitat categories in the following proportions: unlogged upland 37%; logged upland 50%; unlogged riparian 10%; and logged riparian 3%. Dot grid estimates of the proportions of each category on summer home ranges were used to compare deer habitat to random areas. Adult home ranges differed significantly from random areas in all 4 habitat categories

Table 2. Habitat selection within home ranges, by deer monitored 2 years.

	Upland		Riparian	
Deer	1980	1981	1980	1981
	Unlogged Upland		Unlogged Riparian	
1-9	-	0	+	0
2-10	-	-	+	+
2-8	0	0	0	0
1-3	0	-	0	+
1-11	-	0	+	0
1-2	0	-	+	0
2-1	0	0	0	+
1-6	0	-	0	+
	Logged Upland		Logged Riparian	
1-9	0	0	0	0
2-10	0	0	0	0
2-8	-	0	0	0
1-3	0	0	0	0
1-11	0	0	0	0
1-2	0	0	0	0
2-1	0	0	0	0
1-6	0	0	0	0

+, deer used the habitat more than expected;
-, deer used the habitat less than expected;
0, no significant difference between use and availability, 90% simultaneous (97.5% individual) confidence intervals.
Actual values are in Appendix II.

($P < 0.10$). Adults had significantly more of the 2 riparian habitats and unlogged upland, and significantly less logged upland than was found on random areas (Fig. 6). Yearling home ranges resembled random areas except that they contained significantly more logged riparian habitat than random areas did ($P < 0.10$, Fig. 6).

Comparisons between individual home ranges and random areas were generally similar to the pooled data, with the following exceptions. The range of 1 adult (1-8) had significantly less unlogged riparian habitat, and that of another (1-9) significantly less logged riparian than expected from random areas. Ranges of 2 adults (1-8 and 1-7) contained significantly less unlogged upland, and 1 of these (1-8) had significantly more logged upland than expected from random areas (Appendix III). Variation in boundaries caused habitat composition in 4 of 8 ranges to change between summers in at least 1 category, from significantly more or less than expected to not significantly different from random areas. Among these ranges, shifts in composition between years showed no consistent pattern (Table 3).

<u>Mapping Units</u>. Ranges of adults (6 composite and 5 single-year ranges) contained an average of 10 mapping units per 100 ha, and those of 4 yearlings averaged 14. The average area of mapping units was 14 ha per 100 ha deer range. Fifteen random areas contained 8 mapping units per 100 ha, and the average area was 27 ha per 100 ha random area.

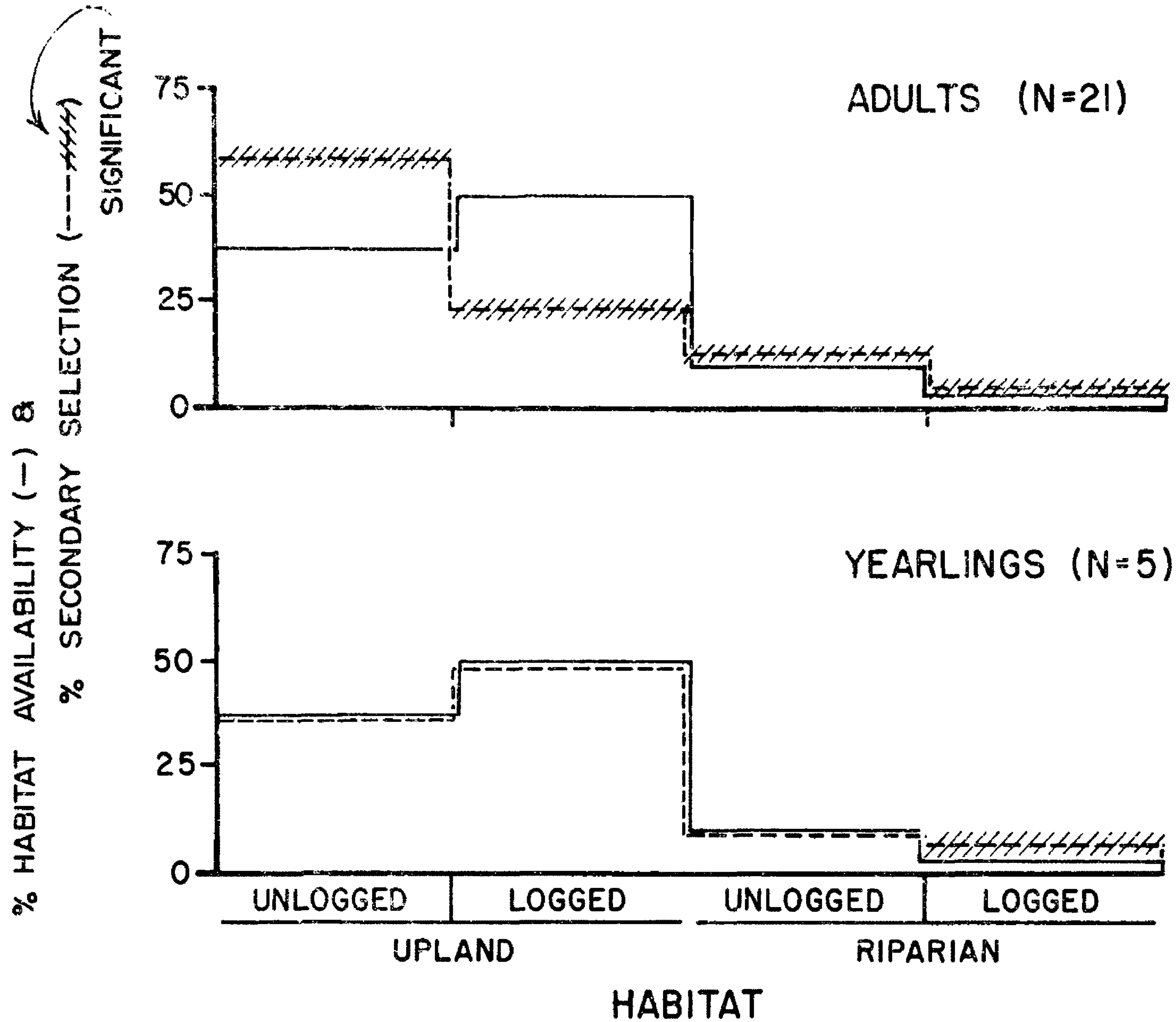


Fig. 6. Comparison of habitat composition on deer ranges, relative to the composition on random areas (secondary selection, Johnson 1980, 90% simultaneous confidence intervals).

Table 3. Summer home range composition for 2 years, relative to composition on random areas.

	Upland		Riparian	
Deer	1980	1981	1980	1981
	Unlogged Upland		Unlogged Riparian	
1-9	+	+	+	0
2-10	+	+	+	+
2-8	0	+	0	0
1-3	+	+	+	+
1-11	0	0	+	+
1-2	0	+	0	0
2-1	0	0	0	0
1-6	+	+	0	0
	Logged Upland		Logged Riparian	
1-9	-	-	-	0
2-10	-	-	0	0
2-8	0	-	0	0
1-3	-	-	0	0
1-11	-	-	0	0
1-2	0	-	0	0
2-1	0	-	0	0
1-6	-	-	0	0

+, deer range contained significantly more than expected from random areas;
-, deer range had significantly less;
0, no significant difference between composition on deer range and that of random areas, 90% simultaneous (97.5% individual) confidence intervals.
Actual values are in Appendix III.

Habitat Types. Adult home ranges contained an average of 9 H.T.s per 100 ha and yearling home ranges had 10 H.T.s per 100 ha. H.T.s characteristic of cool, moist sites predominated. Sixteen were within the spruce (Picea), grand fir (Abies grandis), western red cedar (Thuja plicata), or subalpine fir (Abies lasiocarpa) series (Table 4, Pfister et al. 1977).

The most common H.T.s were Picea/Eqar (on 67% of ranges), Abla/Clun-Xete (60%), Abla/Xete-Vagl (53%), and Abla/Libo-Xete (47%). Mapping units contained 1 H.T., or more often, a mosaic of 2-6 H.T.s (Appendix IV). At least 1 mosaic occurred on every deer summer home range.

Random areas contained 22 H.T.s, most of which also were found on deer summer home ranges; 16 H.T.s were mesic. Frequently occurring types were Abla/Clun-Vaca (67%), Abgr/Clun-Clun (27%), Picea/Clun-Clun (27%), and Picea/Eqar (27%). All random areas contained at least 1 mosaic and an average of 8 H.T.s per 100 ha (Appendix V).

The most common H.T.s on deer summer ranges often were uncommon on random areas (Table 4). These H.T.s included Abla/Clun-Xete, Abla/Xete-Vagl, Abla/Clun-Clun, and Abla/Xete-Vasc. Correspondingly, 4 commonly found H.T.s on random areas were found on relatively few deer summer home ranges. These included Abla/Clun-Vaca, Abgr/Clun-Clun, Picea/Clun-Vaca, and Abgr/Clun-Xete.

Table 4. Frequency and rank of Habitat Types on the study area.

H.T.[a]	Deer Home Ranges Frequency %	Rank	Random Areas Frequency %	Rank
Picea[b]/Eqar[c]	67	1	27	4
Abla/Clun-Xete	60	2	13	12.5
Abla/Xete-Vagl	53	3	7	14
Abla/Libo-Xete	47	4	20	5
Abla/Clun-Clun	47	5	7	19
Picea/Clun-Clun	47	6	27	3
Abla/Vaca	40	7	20	7
Abla/Xete-Vasc	33	8	7	19
Abla/Clun-Mefe	33	9	13	12.5
Abla/Clun-Arnu	27	10	7	19
Abla/Clun-Vaca	20	11.5	67	1
Abla/Mefe	20	11.5	20	8.5
Psme/Syal-Caru	20	13	7	19
Psme/Vaca	13	14.5	7	19
Abla/Alsi	13	14.5	0	0
Picea/Clun-Vaca	13	16	20	6
Thpl/Clun-Mefe	7	17.5	7	15
Abla/Libo-Vasc	7	17.5	0	0
Abgr/Clun-Xete	7	19	20	8.5
Abgr/Clun-Clun	7	22	27	2
Psme/Vagl-Xete	7	22	0	0
Thpl/Clun-Clun	7	22	7	19
Thpl/Clun-Arnu	7	22	13	10.5
Thpl/Opho	7	22	0	0
Abgr/Clun-Arnu	0	0	13	10.5
Picea/Vaca	0	0	7	19

[a]Pfister et al. (1977).

[b]Series Names

Abgr = Abies grandis, grand fir
Abla = Abies lasiocarpa, subalpine fir
Picea = Picea glauca, and P. engelmannii, white spruce, Engelmann spruce
Psme = Pseudotsuga menziesii, Douglas-fir
Thpl = Thuja plicata, western red cedar

[c]Understory Species

Alsi = Alnus sinuata, Sitka alder
Arnu = Aralia nudicaulis, aralia
Caru = Calamagrostis rubescens, pinegrass
Clun = Clintonia uniflora, queencup beadlily
Eqar = Equisetum arvense, common horsetail
Libo = Linnaea borealis, twinflower
Mefe = Menziesia ferrugina, menziesia
Opho = Oplopanax horridum, devil's club
Syal = Symphoricarpos albus, snowberry
Vaca = Vaccinium caespitosum, dwarf huckleberry
Vagl = V. globulare, blue huckleberry
Vasc = V. scoparium, grouse whortleberry
Xete = Xerophyllum tenax, beargrass

Topographic Features. I mapped 12 topographic features on deer summer ranges, 11 on ranges of adults, and 10 on those of yearlings. Ranges of adults and yearlings contained 7 and 8 features per 100 ha, respectively.

The most common topographic features on ranges of adults were potholes and small creeks (each on 82%), and E-SE-S and N-NE-E slopes (each on 45%). Ranges of yearlings contained similar features: potholes (100%), small creeks (75%), and E-SE-S slopes (75%).

Random areas also contained 12 topographic features, and an average of 7 features per 100 ha. The most common topographic features were small creeks (73%), potholes (47%), and W-NW-N slopes, flats, and undulating (each on 33%).

Adult summer ranges, relative to random areas, contained significantly more of the following: N-NE-E slopes, E-SE-S slopes, S-SW-W slopes, wet benches, and small creeks ($P < 0.12$). In contrast, ranges of adults had significantly fewer W-NW-N slopes, flats, undulating, and main streams. Similarly, yearling ranges had significantly more of N-NE-E slopes, E-SE-S slopes, and small creeks, and significantly less of W-NW-N slopes, dry benches, flats, and potholes (Table 5).

Cover-Successional Types. Deer summer home ranges were composed of 8 cover-successional types. Adult and yearling ranges

Table 5. Comparison of topographic features on random areas and deer summer home ranges.

Topographic Feature	Random Areas n = 15 %	Adults' Ranges n = 11 %	Significance[a]	Yearlings' Ranges n = 4 %	Significance
N-NE-E slopes	8	16	+	21	+
E-SE-S slopes	7	22	+	17	+
S-SW-W slopes	5	16	+	5	0
W-NW-N slopes	11	0	-	5	-
Dry benches	4	4	0	1	-
Wet benches	7	16	+	5	0
Flats	22	4	-	0	-
Undulating	24	6	-	27	0
Main streams	1	0.3	-	2	0
Small creeks	5	10	+	14	+
Potholes	7	5	0	3	-
Avalanche chutes	0	0.5	0	0	0

[a]Differs significantly from availability on random areas; +, significantly more; -, significantly less; 0, no significant difference; 88% simultaneous (99% individual) confidence intervals.

each included 7 types, 6 of which were similar. Adults and yearlings had 4 and 6 types per 100 ha, respectively. The most frequent cover-successional types on ranges of adults were open canopy lodgepole (on 64%), shrub-seedling-sapling (64%), selection cut (45%), and old-growth *Abies lasiocarpa* (36%). Common types on yearling ranges were shrub-seedling-sapling (100%), mature seral (75%), selection cut (50%), and open canopy lodgepole (50%).

Random areas contained 6 different cover-successional types, and 4 types per 100 ha. The most common of these were shrub-seedling-sapling (on 53% of areas), mature seral (47%), selection cut (40%), and pole lodgepole (20%).

Ranges of adult deer, relative to random areas, had significantly more open canopy lodgepole and old-growth within the *Abies lasiocarpa* and *Picea* series. The ranges had significantly less shrub-seedling-sapling, pole lodgepole, mature seral, and old-growth *Thuja plicata* ($P < 0.14$). Ranges of yearlings had significantly more open canopy lodgepole and significantly less pole lodgepole, mature seral, old-growth *Thuja plicata*, and selection cut (Table 6).

Vertical Vegetative Cover. I recorded 18 cover board readings per 100 ha on each home range. On ranges of adults, visibility varied from 0 to 100% ($\bar{x} = 32\%$). The greatest difference between 2 cover board readings from 1 common point was 80% (90% and 10%). The

Table 6. Comparison of cover-successional types on random areas and deer summer home ranges.

Cover-successional Type	Random Areas n = 15 %	Adults' Ranges n = 11 %	Significance[a]	Yearlings' Ranges n = 4 %	Significance
Shrub-seedling-sapling	24	20	-	23	0
Pole lodgepole	20	8	-	6	-
Open canopy lodgepole	10	27	+	35	+
Mature seral (mixed species)	22	10	-	17	-
Old-growth, Psme dominant	0	0	0	1	0
Abgr dominant	0	0	0	0	0
Thpl dominant	3	0	-	0	-
Abla dominant	0	12	+	1	0
Picea dominant	0	2	+	0	0
Selection cut	22	22	0	17	-

[a]Differs significantly from expected on random areas; +, significantly more; -, significantly less; 0, no significant difference; 86% simultaneous (98% individual) confidence intervals.

smallest difference was 0%, and the mean difference between pairs was 22%. Cover on yearling ranges varied from 0 to 95% visibility ($\bar{x}$ = 31%). The largest difference in a pair of points was 85% (95% and 10%); the smallest difference was 0% ($\bar{x}$ = 23%).

I made 13 cover board readings per 100 ha on random areas. Vertical cover ranged from 0 to 90% visibility ($\bar{x}$ = 32%). The largest difference in a sampling pair was 85% (90% and 5%), the smallest difference was 0%, and the mean difference was 23%. Mean cover board readings for adults, yearlings, and random areas were similar (Kruskal-Wallis $P > 0.05$).

Community Type and Diversity Index. I identified 97 community types on deer summer home ranges. These were unique combinations of H.T., cover-successional type, and topographic feature. Ranges of adults had 122 types per 100 ha, and those of yearlings contained only 68 per 100 ha. The most common community types on ranges of adults were Picea/Eqar--small creek (on 45%), and Picea/Clun H.T.s--small creek (36%). All other upland types occurred on only 1 or 2 ranges. The most frequent community types on ranges of yearlings were potholes (100%), Abla/Clun H.T.s--small stream (75%), Picea/Clun H.T.s--small stream (75%), Picea/Eqar--small stream (75%), Abla/Clun H.T.s--mature seral--on N-NE-E slopes (50%), and Abla/Clun H.T.s--shrub-seedling-sapling--on E-SE-S slopes (50%). All other upland types were found on only 1 range.

Habitat type mosaics and the presence of discrete riparian units on summer home ranges accounted for the numerous community types and overall diversity. Diversity indices based on the number of discrete H.T.s and riparian units divided by the total area ranged from 6.3 to 28.9 ($\bar{x} = 13.4$) on ranges of adults (Fig. 7). Ranges of yearlings had somewhat higher indices than those of adults, ranging from 7.3 to 25.9 ($\bar{x} = 14.8$). In contrast, random areas had lower diversity indices than those of deer, varying from 3.4 to 15.5 ($\bar{x} = 7.7$). Deer home ranges were significantly more diverse than random areas (Mann-Whitney test, $P = 0.0037$).

DISCUSSION

Distribution of Summer Home Ranges

Deer established summer home ranges from 6 to 40 km south of the winter range where they were marked. Summer home ranges were dispersed throughout the study area, indicating that a variety of places provided suitable deer habitat. Six of 18 ranges were located in the southwestern quarter of the Swan Valley, where Mundinger (1979) determined deer were most concentrated in summer. Gaps between the identified home ranges included home ranges of unmarked deer and probably some areas of unsuitable habitat.

Home ranges of radioed adults did not overlap and the distribution of ranges may have reflected social behavior to avoid other does.

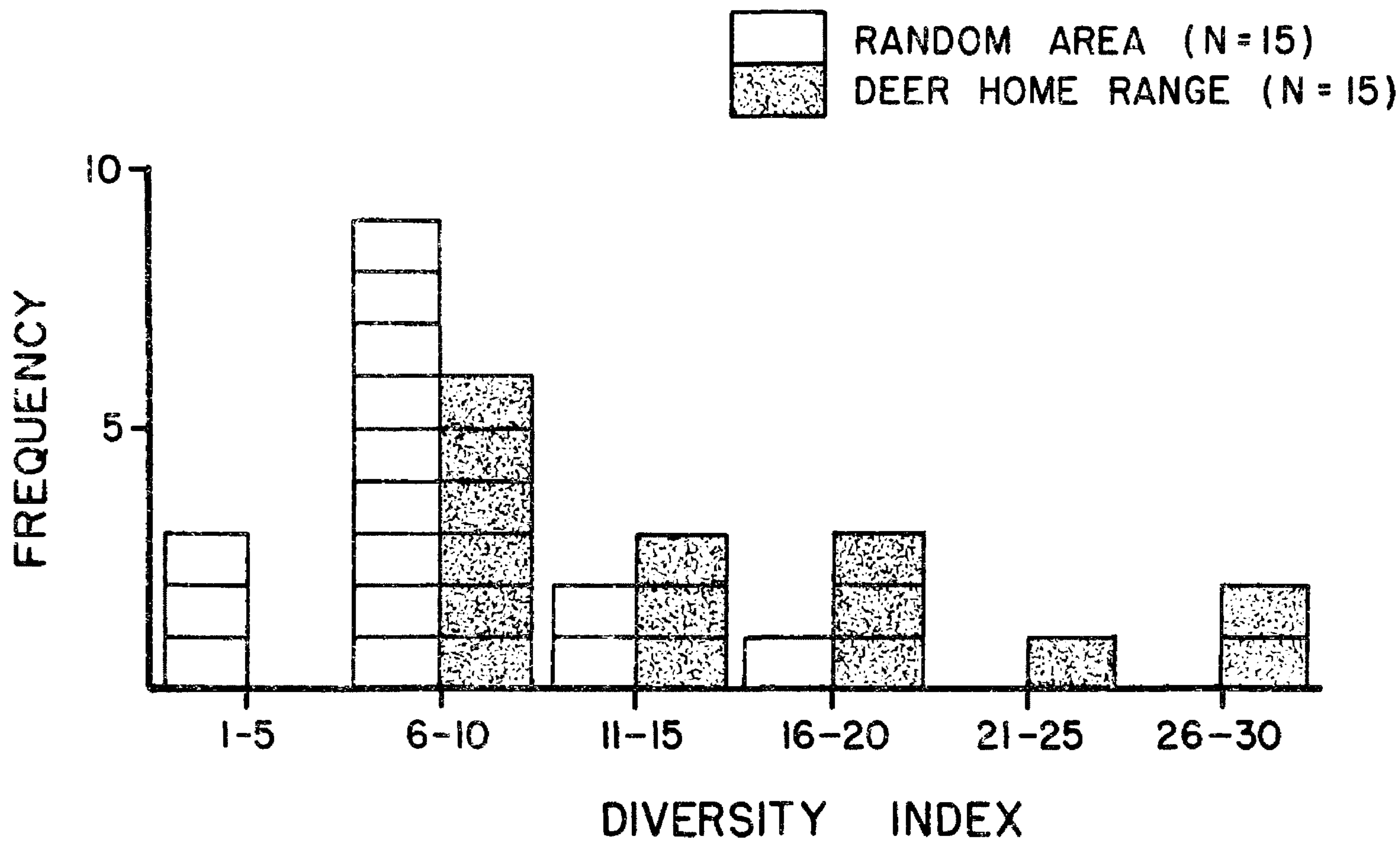


Fig. 7. Diversity indices of deer home ranges and random areas.

Ozoga et al. (1982) demonstrated that does seek isolation and exhibit hostile behavior toward former group members. They concluded that the post-partum doe's exclusive use of fawning areas constituted territorialism, consistent with Pitelka's (1959) definition of territory as an area used exclusively by the occupant. Similarly, Dasmann and Taber (1956) described the mechanism of home range placement in black-tailed deer (O. hemionus columbianus) as mutual antagonism between adult does, reinforced by learning. They reported an incident where certain adult does died, yet their home range centers continued to be avoided by adjacent does. The advantages of avoiding other deer include undisturbed imprinting (Lent 1974), predator avoidance (Miller 1974), and preservation of fawning grounds for exclusive use by family groups (Ozoga et al. 1982).

I could not confirm territorialism with free-ranging telemetered does, but the behavior of the dam and yearling with overlapping ranges was similar to that described by Ozoga et al. (1982). The adult sought solitude in June, and thereafter I saw her with her fawns; simultaneously, the yearling shifted to an adjacent range. Similarly, yearling 2-3 shifted from her dam's previously delineated range to an adjacent area at about fawning time. In other instances, I observed aggressive behavior by adult does toward group members in spring. Also, all telemetered adults either were solitary, or associated only with their fawns.

Two other adult-yearling pairs had overlapping home ranges, but were separated spatially or temporally. In neither case did I observe the adults with young-of-the-year. Both yearlings, however, made excursions from their ranges, possibly as reconnaissance for subsequent dispersal. When the adjacent does were reproductively unsuccessful, the yearlings were allowed to reoccupy their ranges, consistent with Ozoga et al. s' (1982) finding that unsuccessful mothers sought the company of other deer.

The remaining 2 yearlings possibly dispersed. One was located with her presumed dam until early May, then moved 15 km to establish her own home range. The other yearling shifted use between 2 core areas. I believed the original site was the dam's home range and the yearling dispersed to the second site where she was located more often. I detected 8 shifts between the 2, but after 13 July she was always at the second area. Dispersal by these yearlings was probably caused by maternal antagonism.

At high population densities, available habitats are occupied and deer without established ranges disperse to unoccupied areas (Adams 1960, Marshall and Whittington 1968, Hawkins and Montgomery 1969).

Several authors have reported that family groups break up when does drive yearlings away at fawning time (Hungerford 1970 in mule deer, O. h. hemionus; Hawkins and Klimstra 1970, Hawkins et al.

1971, Gladfelter 1978, and Ozoga et al. 1982 in white-tails; and Klein and Strandgaard 1972 in roe deer, Capreolus capreolus). Zalunardo (1965), and Robinette (1966) reported dispersal by mule deer yearlings. In contrast, Nelson and Mech (1981) observed no yearling dispersal by white-tailed deer in Minnesota, perhaps because of low population density. Nelson (1979) reported selection against dispersal because of increased predation by wolves when deer left familiar areas. The latter 2 studies probably had little application to white-tailed deer ecology in the Swan-Clearwater because of the profound influence wolf predation had on Minnesota deer behavior and habitat use.

Fidelity to Summer Home Range

White-tailed deer in the Swan-Clearwater drainages returned annually to their summer home ranges, a pattern also documented by Progulske and Baskett (1958), Hoskinson and Mech (1976), and Janke (1977).

One advantage of annual fidelity by matriarchal does is the retention of successful fawning grounds for family groups as reported by Ozoga et al. (1982), who hypothesized that this behavior would enhance the reproductive success of matriarchs during times of high population densities and stress. Fidelity also increases familiarity with food and escape habitat within a doe's home range, increasing her ability to utilize them.

Dahlberg and Guettinger (1956) concluded that deer in Wisconsin showed an affinity for areas, but that no homing abilities were involved. Rather, deer were thought to make random movements to general areas that satisfied habitat requirements. However, Verme (1973) noted a remarkably high return rate of Michigan deer after transport to unfamiliar areas, despite deep snows, long distances, and close proximity of release sites to deer yards. Dasmann and Taber (1956), Gruell and Papez (1963), Zalunardo (1965), Byford (1970), and Bertram and Rempel (1977) postulated that deer learned the location of seasonal ranges from their dams. Where wolves and deer coexist, Nelson (1979:8) concluded that "home range location and therefore, habitat availability, is determined more by early social experience, learning, and tradition than by some innate ability to select the best habitat." Nelson and Mech (1981) suggested that deer showed annual fidelity to ranges because the most successful deer had ranges between wolf pack territories, and selection favored deer returning to these secure areas. Learning migration routes and suitable summer home range habitat is probably important in the Swan-Clearwater because all dams and their presumed young were located together for approximately 1 year after the young were born.

Summer Home Range Size

I used convex polygons to delineate home ranges so that size could be reliably compared to results of previous studies. One shortcoming of the method was that it often included unused areas in the home range, particularly for the 3 deer that used 2 widely separated core areas. The sum of polygons around each core area would have better represented the amount of habitat actually used.

By the Odum and Kuenzler (1955) method, I had an adequate sample size in only approximately half of the home ranges. Nevertheless, the data were still useful because, when mapped, relocations could always identify core areas of deer use. Home range sizes of 3 deer that were monitored for 24-hour periods showed little increase from previously delineated ranges, indicating home ranges were adequately delineated during daytime tracking. Alternative methods of home range delineation include adjusting polygon boundaries with "knowledge of the habitat rather than a mechanical procedure" (Marchinton and Jeter 1966:192). The method more accurately reflects the occupied area, but is not duplicable. Also, workers have used grid home ranges (Rongstad and Tester 1969) that reflected area and intensity of use, and ellipses (Jennrich and Turner 1969) that represented area but ignored habitat significance.

Average home range sizes in the Swan-Clearwater were generally smaller than those reported in other studies (Table 7), probably reflecting diverse habitat that is capable of meeting the needs of deer in small areas. The largest home ranges contained more than 1 core center of activity, indicating the distribution of key resources

Table 7. Comparison of average summer home range sizes derived during 10 studies of white-tailed deer.

Average Home Range Size (ha)	N (does or mostly does)	Method	State	Source
74	26	telemetry, convex polygon	Montana	this study
83	5	telemetry, convex polygon	Minnesota	Nelson and Mech 1981
94	4	telemetry, concave polygon	Idaho	Owens 1981
<259	8	telemetry, convex polygon	Montana	Janke 1977
211	13	telemetry, convex polygon	Minnesota	Hoskinson and Mech 1976
114	3	telemetry, convex polygon	Minnesota	Kohn and Mooty 1971
259	8	telemetry and mark/observe, convex polygon	South Dakota	Sparrowe and Springer 1970
42	1	telemetry, adjusted minimum area	Alabama	Byford 1969
93	1	telemetry, convex polygon	Florida	Marchinton 1964
160	9	mark/observe, convex polygon	Missouri	Progulske and Baskett 1958

in the study area.

Sanderson (1966) outlined 3 factors leading to reduced home range sizes in animals, and other workers have applied these to summering white-tailed deer: 1) doe-fawn interactions including fawning and raising young (Hawkins and Klimstra 1970, Gladfelter 1978, Ozoga et al. 1982); 2) high population densities (Marchinton and Jeter 1966, Marshall and Whittington 1968, Smith 1970); and 3) abundant and high quality habitat (Townsend and Smith 1933, Thomas et al. 1964, Marchinton and Jeter 1966, Miller 1970, Sparrowe and Springer 1970).

Habitat Selection

Habitat selection can be considered as a hierarchy (Johnson 1980), where primary selection involves the geographical range of the species, secondary selection involves the location of home ranges within the geographical range, and tertiary selection involves the use of specific habitats within the home range. Tertiary selection, the only level considered in many studies, may represent habitat preferences or "the best tradeoffs for the particular set of conditions each individual experiences" (Peek et al. 1982:16). Riparian habitats were used more than expected (preferred) by both age-groups in the Swan-Clearwater, perhaps because of preferred and abundant food and cover found there. Changes in plant phenology and the presence of lush growth throughout the season probably contributed to preference of riparian areas. Similar preferences by white-tailed deer were reported by Townsend and Smith (1933), Severinghaus and Cheatum (1956), Progulske and Duerre (1964), Allen (1968), Martinka (1968), and Mundinger (1979).

In my study, deer apparently preferred unlogged riparian habitat because only 2 (1-8 and 2-3, Appendix II) used logged riparian more than expected. Summer ranges of those deer contained almost no unlogged riparian habitat, but they were apparently suitable because the logged riparian was widespread and contained abundant deciduous cover and remnant conifers.

Deer used upland habitats less than expected, regardless of whether the habitat was relatively common or rare, or logged or unlogged. In addition, I observed no nocturnal shifts into forest openings by deer tracked for 24-hour periods, which differs from findings by Montgomery (1963), Marchinton and Jeter (1966), and Smith (1970). Results in the Swan-Clearwater contrast with the long-held notion that mature or virgin timber is unsuitable white-tailed deer habitat (Morton and Sedam 1938, Lay and Taylor 1943). Several authors (Westell 1954, Verme 1965) recommended cutting to produce forage and diversity for deer. However, Pengelly (1972) noted that if forage is not limiting, timber harvest may destroy valuable cover. Wallmo and Schoen (1980:453) found a 5.3:1 mean summer ratio of deer use in overmature forest:young growth by Sitka black-tailed deer (O. h.

sitkensis) in southeast Alaska. They concluded that deer could not be universally categorized as early-successional animals.

The semantics of the term maturity may cause some misunderstanding (Wallmo and Schoen 1980). Silviculturally mature stands, characterized by even-aged trees, closed canopy, and little understory growth, were poor habitat for deer. But those stands were not serally mature. Wallmo and Schoen (1980:457) described the uneven-aged forest, where "the forest floor has a scattering of decaying remains of ancient trees and a few recently fallen trees, occasional small openings with shrub thickets, an abundance of forbs, and much unobstructed walking space for deer. On sunny days, one is impressed with the many light areas in the forest in contrast to the uniform darkness of even-aged stands." Clearly, these were diverse stands, providing both food and cover in close proximity. Similarly, relatively open, uneven-aged and silviculturally overmature stands provided high quality summer deer habitat in the Swan-Clearwater.

Underuse of uplands may not reflect their importance, however. Deer could have traveled through uplands extensively, but the technique I used to delineate tertiary selection may not have identified light use. Johnson (1980) cautioned that time spent using a habitat does not always imply its value. Uplands, especially in mature timber, probably have some importance to Swan-Clearwater deer, but its relative value is probably lower than that of riparian habitats.

Comparison Between Summer Home Ranges and Random Areas

Secondary selection (where an animal establishes its home range) was identified by comparisons between summer home ranges and random areas. Peek et al. (1982) suggested that secondary selection could determine a standard of home range quality, used to identify habitat requirements. Therefore, I used secondary selection by adult does to determine such a standard in the Swan-Clearwater.

Habitat Category. Collectively, adult home ranges contained significantly more of the riparian habitats (unlogged and logged) and unlogged upland than was present on random areas. The preponderance of the riparian habitats was consistent with tertiary selection for them. At both the secondary and tertiary levels, use of logged riparian was most common where deciduous cover had developed and patches of mature conifers remained. Secondary selection for unlogged upland, however, contrasted with tertiary selection against it. Thus, unlogged upland was an important component of home ranges, although it was utilized less than expected at the tertiary level. Deer may have located home ranges in areas of unlogged upland for security and diversity. Adult ranges contained significantly less logged upland than available on random areas, consistent with tertiary selection against this habitat.

Although adults and yearlings used their home ranges similarly (tertiary selection), they established their ranges in different habitats (secondary selection). Yearling ranges resembled random areas except they had significantly more logged riparian habitat. Adults used unlogged riparian, logged riparian, unlogged upland, and logged upland, in that order. Thus, the secondary selection of logged riparian by yearlings may mean that logged riparian was the most preferred habitat available to them. Apparently, yearlings were forced to occupy the marginal (i.e., logged) habitats. Similar displacement of yearlings to suboptimal habitats has been observed among roe deer in Denmark (Klein and Strandgaard 1972) and among mule deer in the Missouri River Breaks of central Montana (Hamlin pers. comm.). Yearlings compensated for unavailable preferred habitats, as 2 adults did, by selecting logged riparian habitat that contained abundant deciduous cover and remnant conifers.

Deer tracked during both summers in the Swan-Clearwater showed some variability in secondary and tertiary selection. Among deer, shifts were not consistent and probably were not caused by 1 study-wide factor. Sample sizes were probably adequate for secondary selection (because I used a large number of grid points to estimate composition), but may have been inadequate for tertiary selection (because of inadequate relocations). True shifts in selection were unlikely because the changes never were between extremes. Apparently, an animal's familiarity with its small home range allowed a deer to shift selection to meet its needs, as reported by Inglis et al. (1979).

Shifts I observed reflected the necessity of diversity in a small home range, because diversity provided the preferred habitats in close proximity, which allowed a deer more opportunities for choices to meet its needs.

Mapping Units, H.T.s, Topographic Features, Cover-Successional Types, and Vertical Vegetative Cover. Comparisons of the average density of mapping units, H.T.s, topographic features, and cover-successional types showed that yearling ranges had slightly higher diversity than those of adults and random areas (Table 8). Possibly yearlings compensated for marginal (logged) habitat by selecting diverse upland habitats.

More ecotones were encountered on deer ranges than on random areas, more mapping units were delineated, and mapping units were smaller. Thus, deer ranges were more diverse than random areas.

Mesic H.T.s were common on deer ranges and random areas, reflecting similar conditions throughout the study area. Based upon frequency of occurrence, however, deer sought some mesic H.T.s but avoided others (Table 4). H.T.s that deer sought contained a wide variety of summer foods in the understory. Deer avoided some mesic H.T.s for no apparent reason, although Abla/Clun, Vaca may have been avoided because it was the driest Clun type, occurring on gravelly

Table 8. Average density per 100 ha of mapping units, Habitat Types, topographic features, and cover-successional types on yearling ranges, adult ranges, and random areas.

Habitat Parameter	Yearling Ranges n = 4	Adult Ranges n = 11	Random Areas n = 15
Mapping Units	14	10	8
Habitat Types	10	9	8
Topographic Features	8	7	7
Cover-Successional Type	6	4	4

benches (Arno pers. comm.). Pfister et al. (1977) did not elaborate on summer deer use of H.T.s. Perhaps deer were responding to unexamined features of microclimate, or more likely, selection of H.T.s was incidental to "the mere presence of dense coniferous cover in seral communities" (Mundinger 1979:56).

Topographic features selected by deer were riparian (small creeks) and cool, mesic uplands (E-SE-S and N-NE-E slopes, and wet benches), with 1 exception. Adults selected S-SW-W slopes, perhaps because 1 deer's range (1-12) contained much of it, albeit in high elevational, cool forested slopes of the Swan Mountains. Deer selected against dry topographic features and those with low diversity (dry benches, flats, undulating, and W-NW-N slopes). However, deer also selected against 2 riparian features: adults selected against main streams, and yearlings against potholes. Two random areas had a preponderance of each feature, and the differences in the proportions were small, resulting in apparent avoidance by deer. Because random areas were not necessarily non-deer areas, differences between them and deer ranges were not always pronounced.

Deer ranges contained significantly more open canopy lodgepole than random areas did, reflecting the importance of mature subclimax cover that often results from fire (Antos 1977). Adults also selected more old-growth in the Abla and Picea series than were found on random areas. The indicated climax tree species is probably less important than the presence of dense coniferous cover (Mundinger 1979). Dense conifers protect deer from adverse weather. "In summer, tree crowns reflect heat; the denser and taller the stand, the less heat that reaches the air and soil beneath" (Drolet 1976:133). Deer ranges contained significantly less pole lodgepole, mature seral, and old-growth Thpl types than random areas did, perhaps because of associated depauperate understories. Home ranges of yearlings had significantly less of the selection cut type than random areas did, but the difference was small (17% vs. 22%).

Vertical vegetative cover was variable on deer ranges and random areas, indicating diversity throughout the study area. Cover diversity allowed deer to move short distances for hiding. Mean visibility was similar on deer ranges and random areas (31-32%), which may indicate adequate hiding cover on much of the study area. Although clearcuts and timbered areas often gave similar visibility readings, deer were much more easily seen in the former, particularly if they were moving.

Community Types and Diversity Indices. Deer ranges contained seemingly random combinations of preferred H.T.s, topographic features, and cover-successional types as unique community types. Most community types occurred on only 1 or 2 deer ranges. Similarly, Pierce (1975) noted deer were individualistic in using a wide variety of habitats, complicating his determination of the important habitats for deer. Nelson and Mech (1981) also found that deer ranges contained a wide variety of upland forest types. Interspersion of riparian units and discrete H.T.s, was common among deer ranges, resulting in diversity indices significantly higher than those on random areas. Dahlberg and Guettinger (1956) and Progulske and Duerre (1964) stressed the importance of interspersion of openings and water as a desirable component of summer range. Marchinton and Jeter (1966) concluded that the interspersion of foods changing in availability through time enabled deer to restrict movements to small home ranges. In my study, yearlings had a higher mean diversity index than adults (14.8 compared to 13.4), again reflecting possible compensation for marginal (logged) riparian habitat. Adults may have required less interspersion than yearlings because their ranges were in preferred unlogged riparian areas.

Summary and Conclusions

Deer movements, fidelity, home range juxtaposition, and home range size reflect strategies of habitat utilization. This may contribute to population stability (Mundinger 1981) in the study area. Partitioning of summer range began with doe isolation and erratic yearling movements (excursions, shifts, and dispersal). Once separated from each other, deer used past experience and learning to choose a home range that provided certain key habitat and security features. In the Swan-Clearwater, an "average" adult summer home range was approximately 70 ha and contained more than expected riparian habitat, unlogged uplands, and diversity. Habitat components were in close proximity, allowing a deer to maintain small home range size and shift habitat selection to meet its needs. In selecting the above, deer may have incidentally selected a variety of mesic H.T. s and topographic features, and mature subclimax cover-successional types. The average vertical visibility was 31%.

Most yearlings and 2 adults demonstrated a degree of adaptability by selecting home ranges in marginal habitats. Their home ranges usually were logged extensively, but contained much riparian habitat, deciduous cover, and remnant patches of mature forest. Otherwise, they were physiographically similar to preferred areas.

Logged uplands in random areas usually equalled or exceeded the amounts found on deer home ranges. Thomas et al. (1979) speculated that logging created diversity and improved wildlife habitat. In my study, the few deer whose summer home ranges contained more logged upland than expected from random areas always used it less than expected. Thus, deer apparently tolerated rather than required logged uplands. Once summer home ranges were established, deer remained within these relatively restricted areas throughout the season.

Within home ranges, adults and yearlings selected similar habitats; both preferred riparian areas. However, yearlings located their ranges in habitats that differed from those selected by adults, probably reflecting displacement to marginal habitats. To compensate for missing preferred habitats (unlogged riparian and upland), yearlings selected logged riparian habitat that contained abundant cover and diversity.

MANAGEMENT RECOMMENDATIONS

Deer preferred riparian and unlogged habitats in small, diverse home ranges. Adult home ranges contained an average of 2 cutting units of about 12 ha each, per 100-ha home range. I found no evidence that logging improved deer habitat. Therefore, to provide optimal white-tailed deer summer habitats within the multiple-use concept, the following guidelines should be applied in the Swan-Clearwater.

1. Protect riparian areas from logging activities.

2. Maintain mesic sites contiguous with larger areas of forested upland.

3. Preferred Management: maintain continuous forest upland mosaics with uneven-age silvicultural systems and prescribed fires.

4. Alternative: employ even-aged management within these constraints:

   a. Plan the maximum cutting unit size as 12 ha.

b. Plan only 2 cutting units per 100 ha, or 5 per section.

c. Limit post-logging scarification to the minimum necessary to provide for tree reproduction. This should enhance shrub production to provide deer forage and cover.

d. Make additional entries only after second growth in logged units is sufficiently developed to provide hiding cover which Thomas et al. (1979:109) defines as "vegetation capable of hiding 90% of a standing adult deer from the view of a human at a distance equal to or less than 61 m."

5. Deer summer areas of special management concern:

a. Deer are most concentrated during summer in the southwestern portion of the study area, which is predominantly unlogged. Logging there will reduce optimal habitat.

b. The area between Elk and Jim creeks has been extensively logged and remnant conifer stands now provide cover that should be retained until second growth develops.

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APPENDIX I

DESCRIPTION OF STUDY ANIMALS

Deer no.	Ear tag no.	Age at capture	Collar description	Capture date	Winter range	Summer range
ADULTS						
1-9	A-7293 A-7294	2½	green	2/79	Cedar Cr.	Lindbergh Lake
2-10	A-7207 A-7208	2½	red/yellow/black	2/79	Dog Cr.	Lindbergh Lake
2-8	A-6083 A-6084	2½	green/yellow	2/78	Goat Cr.	Red Butte
1-3	A-6113 A-6114	1½	yellow/black	2/78	Pony Cr.	Marshall Cr.
1-11	A-7309 A-7310	1½	red/blue	2/79	Dog Cr.	Kaufman Rd.
1-2	A-6099 A-6100	3½	red/green	2/78	Dog Cr.	Foss Ranch
2-1	A-7342 A-7343	2½	blue/yellow	3/79	Goat Cr.	Summit Lake
1-6	A-7283 A-7284	3½	black	2/79	Lion Cr.	Richmond Cr.
2-11	--- ---	3½	died, winter 80-81	78	Goat Cr.	Crystal Lake
1-7	--- ---	3½	died, winter 80-81	79	Dog Cr.	Windfall Cr.
1-8	A-7607 A-7608	adult	white	2/81	Dog Cr.	Cold Cr.
1-12	A-7613 A-7614	1½	white	2/81	Dog Cr.	Clearwater Lake
1-4	A-7619 A-7620	3½	white	2/81	Simpson Cr.	Colt Cr.
YEARLINGS						
1-5	A-7605 A-7606	½	white	2/81	Van Lake	Herrick Run Cr.
2-3	A-7611 A-7612	½	white	2/81	Dog Cr.	Cold Cr.
2-2	A-7631 A-7632	½	white	3/81	Van Lake	Lindbergh Lake
2-5	A-7633 A-7634	½	white	3/81	Dog Cr.	Holland Cr. - Divide
2-4	A-7617 A-7618	½	white	2/81	Simpson Cr.	Colt Cr.

APPENDIX II

HABITAT USE BY WHITE-TAILED DEER IN 1980 AND 1981 (after Neu et al. 1974)

Deer and year	Habitat category	Total acreage	Proportion of total acreage (pi_o)	Number of deer locations	Expected number of deer locations[a]	Proportion observed in each habitat[b] ($\bar{p}i$)	Confidence interval on proportion of occurrence[c]
ADULTS							
1-11	unlogged upland	21.75	0.45	10	16.2	0.28	$0.12 \leq 0.45 \leq 0.4$ (-)[d]
1980	logged upland	5.9	0.12	2	4.32	0.06	$-0.03 \leq 0.12 \leq 0.15$
	unlogged riparian	20.5	0.43	24	15.48	0.66	$0.49 \leq 0.43 \leq 0.83$ (+)
	logged riparian	0.0	0.0	0	0.0	0.0	---
	TOTAL	48.15		36	36.0		
1-11 1981	N/A[e]						
1-9	unlogged upland	606.40	0.85	7	16.15	0.37	$0.12 \leq 0.85 \leq 0.62$ (-)
1980	logged upland	35.77	0.05	0	0.95	0.0	---
	unlogged riparian	70.20	0.1	12	1.9	0.63	$0.38 \leq 0.1 \leq 0.88$ (+)
	logged riparian	2.62	0.004	0	0.08	0.0	---
	TOTAL	714.99		19			

[a] To calculate, multiply pi_o X N; i.e., 0.45 X 36 = 16.2.

[b] To calculate, divide the number of locations in each category by N, i.e., 10 ÷ 36 = 0.28.

[c] To calculate, use the formula $\bar{p}i \pm Z_{(1-\alpha/2k)} \sqrt{(\bar{p}i)(1-\bar{p}i)/N}$. For 4 habitat categories, Z = 2.24.

[d] (+), deer used the habitat significantly more than expected from the proportion of availability.
(-), deer used the habitat significantly less than expected.

[e] χ^2, not significant.

APPENDIX II (continued)

Deer and year	Habitat category	Total acreage	Proportion of total acreage (pi_o)	Number of deer locations	Expected number of deer locations[a]	Proportion observed in each habitat[b] ($\bar{p}i$)	Confidence interval on proportion of occurrence[c]
1-9	unlogged upland	373.84	0.68	8	12.24	0.44	$0.18 \leq 0.68 \leq 0.70$
1981	logged upland	120.47	0.22	4	3.96	0.22	$0.0 \leq 0.22 \leq 0.44$
	unlogged riparian	41.48	0.08	5	1.44	0.28	$0.04 \leq 0.08 \leq 0.52$
	logged riparian	12.68	0.02	1	0.36	0.06	$-0.07 \leq 0.02 \leq 0.19$
	TOTAL	548.47		18			
2-10	unlogged upland	97.83	0.72	17	23.04	0.53	$0.36 \leq 0.72 \leq 0.70$ (-)
1980	logged upland	0.0	---	---	---	---	---
	unlogged riparian	38.0	0.28	15	8.96	0.47	$0.30 \leq 0.28 \leq 0.64$ (+)
	logged riparian	0.0	---	---	---	---	---
	TOTAL	135.83		32			
2-10	unlogged upland	74.39	0.79	10	17.38	0.45	$0.24 \leq 0.79 \leq 0.66$ (-)
1981	logged upland	0.0	---	---	---	---	---
	unlogged riparian	19.7	0.21	12	4.62	0.55	$0.34 \leq 0.21 \leq 0.76$ (+)
	logged riparian	0.0	---	---	---	---	---
	TOTAL	94.09		22			
2-8	unlogged upland	22.64	0.31	4	2.79	0.45	$0.08 \leq 0.31 \leq 0.82$
1980	logged upland	44.10	0.61	2	5.49	0.22	$-0.09 \leq 0.61 \leq 0.53$ (-)
	unlogged riparian	3.76	0.05	3	0.45	0.33	$-0.02 \leq 0.05 \leq 0.68$
	logged riparian	2.43	0.03	0	0.27	---	---
	TOTAL	72.93		9			

APPENDIX II (continued)

Deer and year	Habitat category	Total acreage	Proportion of total acreage (pi_o)	Number of deer locations	Expected number of deer locations[a]	Proportion observed in each habitat[b] ($\bar{p}i$)	Confidence interval on proportion of occurrence[c]
2-8 1981	N/A						
1-3 1980	N/A						
1-3 1981	unlogged upland	143.8	0.78	2	8.58	0.18	$-0.08 \leq 0.78 \leq 0.44$ (-)
	logged upland	11.1	0.06	0	0.66	0.0	---
	unlogged riparian	28.1	0.15	9	1.65	0.82	$0.56 \leq 0.15 \leq 1.08$ (+)
	logged riparian	1.3	0.01	0	0.11	0.0	---
	TOTAL	184.3		11			
1-2 1980	unlogged upland	13.63	0.57	13	18.81	0.39	$0.20 \leq 0.57 \leq 0.58$
	logged upland	5.33	0.22	4	7.26	0.12	$-0.01 \leq 0.22 \leq 0.25$
	unlogged riparian	4.15	0.18	13	5.94	0.39	$0.20 \leq 0.18 \leq 0.58$ (+)
	logged riparian	0.657	0.03	3	0.99	0.09	$-0.02 \leq 0.03 \leq 0.20$
	TOTAL	23.767		33			
1-2 1981	unlogged upland	22.79	0.80	5	10.4	0.38	$0.08 \leq 0.80 \leq 0.68$ (-)
	logged upland	0.1225	0.01	2	0.13	0.15	$-0.07 \leq 0.01 \leq 0.37$
	unlogged riparian	5.34	0.18	3	2.34	0.23	$-0.03 \leq 0.18 \leq 0.49$
	logged riparian	0.275	0.01	3	0.13	0.23	$-0.03 \leq 0.01 \leq 0.49$
	TOTAL	28.53		13			

APPENDIX II (continued)

Deer and year	Habitat category	Total acreage	Proportion of total acreage (pi_o)	Number of deer locations	Expected number of deer locations[a]	Proportion observed in each habitat[b] ($\bar{p}i$)	Confidence interval on proportion of occurrence[c]
2-1	unlogged upland	53.05	0.58	9	11.6	0.45	$0.20 \leq 0.58 \leq 0.70$
1980	logged upland	35.54	0.39	8	7.8	0.40	$0.15 \leq 0.39 \leq 0.65$
	unlogged riparian	1.5	0.02	2	0.4	0.10	$-0.05 \leq 0.02 \leq 0.25$
	logged riparian	1.3	0.01	1	0.2	0.05	$-0.06 \leq 0.01 \leq 0.16$
	TOTAL	91.45		20			
2-1	unlogged upland	79.18	0.59	10	11.21	0.52	$0.26 \leq 0.59 \leq 0.78$
1981	logged upland	47.12	0.35	3	6.65	0.16	$-0.03 \leq 0.35 \leq 0.35$
	unlogged riparian	4.59	0.04	6	0.76	0.32	$0.08 \leq 0.04 \leq 0.56$ (+)
	logged riparian	2.33	0.02	0	0.38	0.0	---
	TOTAL	133.22		19			
1-6	unlogged upland	64.88	0.85	9	12.75	0.6	$0.33 \leq 0.85 \leq 0.87$
1980	logged upland	7.85	0.10	2	1.5	0.13	$-0.06 \leq 0.10 \leq 0.32$
	unlogged riparian	4.1	0.05	4	0.75	0.27	$0.02 \leq 0.05 \leq 0.52$
	logged riparian	0.0	---	0	---	---	---
	TOTAL	76.83		15			
1-6	unlogged upland	98.7	0.93	9	14.88	0.56	$0.29 \leq 0.93 \leq 0.83$ (-)
1981	logged upland	4.08	0.04	1	0.64	0.06	$-0.07 \leq 0.04 \leq 0.19$
	unlogged riparian	3.75	0.03	6	0.48	0.38	$0.12 \leq 0.03 \leq 0.64$ (+)
	logged riparian	---	---	0	---	---	---
	TOTAL	106.53		16			

APPENDIX II (continued)

Deer and year	Habitat category	Total acreage	Proportion of total acreage (pi_o)	Number of deer locations	Expected number of deer locations[a]	Proportion observed in each habitat[b] ($\bar{p}i$)	Confidence interval on proportion of occurrence[c]
2-11 1980	N/A						
1-7 1980	unlogged upland	55.83	0.26	4	5.72	0.18	$0.0 \leq 0.26 \leq 0.36$
	logged upland	119.65	0.56	8	12.32	0.37	$0.14 \leq 0.56 \leq 0.60$
	unlogged riparian	20.31	0.10	4	2.2	0.18	$0.0 \leq 0.10 \leq 0.36$
	logged riparian	17.92	0.08	6	1.76	0.27	$0.06 \leq 0.08 \leq 0.48$
	TOTAL	213.71		22			
1-8 1981	unlogged upland	1.40	0.006	0	0.14	0.0	---
	logged upland	191.98	0.8	7	19.2	0.29	$0.08 \leq 0.8 \leq 0.85$ (-)
	unlogged riparian	1.03	0.004	1	0.1	0.04	$-0.05 \leq 0.004 \leq 0.13$
	logged riparian	45.93	0.19	16	4.56	0.67	$0.46 \leq 0.19 \leq 0.88$ (+)
	TOTAL	240.34		24			
1-12 1981	N/A						
1-4 1981	unlogged upland	118.37	0.77	11	13.86	0.61	$0.36 \leq 0.77 \leq 0.86$
	logged upland	20.34	0.13	2	2.34	0.11	$-0.05 \leq 0.13 \leq 0.27$
	unlogged riparian	15.09	0.10	5	1.8	0.28	$0.05 \leq 0.10 \leq 0.51$
	logged riparian	0.0	---	0	---	---	---
	TOTAL	153.80		18			

APPENDIX II (continued)

Deer and year	Habitat category	Total acreage	Proportion of total acreage (pi_o)	Number of deer locations	Expected number of deer locations[a]	Proportion observed in each habitat[b] ($\bar{p}i$)	Confidence interval on proportion of occurrence[c]
YEARLINGS							
1-5	unlogged upland	3.5	0.04	2	0.92	0.09	$-0.04 \leq 0.04 \leq 0.22$
	logged upland	50.26	0.60	6	13.8	0.26	$0.06 \leq 0.60 \leq 0.46$ (-)
	unlogged riparian	6.3	0.08	7	1.84	0.30	$0.09 \leq 0.08 \leq 0.51$ (+)
	logged riparian	23.62	0.28	8	6.44	0.35	$0.13 \leq 0.28 \leq 0.57$
	TOTAL	83.68		23			
2-3	unlogged upland	14.67	0.10	1	1.9	0.05	$-0.06 \leq 0.10 \leq 0.16$
	logged upland	93.31	0.62	6	11.78	0.32	$0.08 \leq 0.62 \leq 0.52$ (-)
	unlogged riparian	6.97	0.04	2	0.76	0.10	$-0.05 \leq 0.04 \leq 0.25$
	logged riparian	36.04	0.24	10	4.56	0.53	$0.27 \leq 0.24 \leq 0.79$ (+)
	TOTAL	150.99		19			
2-2	unlogged upland	171.33	0.78	10	18.72	0.42	$0.20 \leq 0.78 \leq 0.64$ (-)
	logged upland	11.68	0.05	0	1.2	0.0	---
	unlogged riparian	37.15	0.17	14	4.08	0.58	$0.36 \leq 0.17 \leq 0.80$ (+)
	logged riparian	0.0	---	---	---	---	---
	TOTAL	220.16		24			

APPENDIX II (continued)

Deer and year	Habitat category	Total acreage	Proportion of total acreage (pi_o)	Number of deer locations	Expected number of deer locations[a]	Proportion observed in each habitat[b] ($\bar{p}i$)	Confidence interval on proportion of occurrence[c]
2-5	unlogged upland	99.40	0.19	4	3.80	0.20	$0.0 \leq 0.19 \leq 0.20$
	logged upland	372.41	0.72	5	14.40	0.25	$0.03 \leq 0.72 \leq 0.47$ (-)
	unlogged riparian	19.23	0.04	9	0.80	0.45	$0.20 \leq 0.04 \leq 0.70$ (+)
	logged riparian	23.01	0.05	2	1.0	0.10	$-0.05 \leq 0.05 \leq 0.25$
	TOTAL	514.05		20			
2-4	unlogged upland	110.70	0.70	10	14.7	0.48	$0.24 \leq 0.70 \leq 0.72$
	logged upland	36.88	0.23	4	4.83	0.19	$0.0 \leq 0.23 \leq 0.38$
	unlogged riparian	10.38	0.07	7	1.47	0.33	$0.11 \leq 0.07 \leq 0.55$ (+)
	logged riparian	0.0	---	---	---	---	---
	TOTAL	157.96		21			

APPENDIX III

COMPARISON OF HABITAT COMPOSITION ON DEER HOME RANGES AND RANDOM AREAS IN 1980 AND 1981

Deer and year	Habitat category	Average proportion found on random areas (availability)	Proportion[a] found on deer home range ($\bar{p}i$) (use)	Confidence interval on proportion of availability
ADULTS				
1-9	unlogged upland	0.37	0.76	$0.72 \leq 0.37 \leq 0.80$ (+)[b]
1980	logged upland	0.50	0.07	$0.04 \leq 0.50 \leq 0.10$ (-)
	unlogged riparian	0.10	0.15	$0.11 \leq 0.10 \leq 0.19$ (+)
	logged riparian	0.03	0.01	$0.0 \leq 0.03 \leq 0.02$ (-)
			N = 481	
1-9	unlogged upland		0.57	$0.51 \leq 0.37 \leq 0.63$ (+)
1981	logged upland		0.25	$0.20 \leq 0.50 \leq 0.30$ (-)
	unlogged riparian		0.14	$0.10 \leq 0.10 \leq 0.18$
	logged riparian		0.04	$0.02 \leq 0.03 \leq 0.06$
			N = 361	
2-10	unlogged upland		0.64	$0.53 \leq 0.37 \leq 0.75$ (+)
1980	logged upland		0.0	--- (-)
	unlogged riparian		0.36	$0.25 \leq 0.10 \leq 0.47$ (+)
	logged riparian		0.0	---
			N = 96	
2-10	unlogged upland		0.73	$0.61 \leq 0.37 \leq 0.85$ (+)
1981	logged upland		0.0	--- (-)
	unlogged riparian		0.27	$0.15 \leq 0.10 \leq 0.39$ (+)
	logged riparian		0.0	---
			N = 66	

[a]Proportions were derived from dot grid estimates and may differ from those in Appendix II.

[b](+), deer home range had significantly more than expected from availability on random areas.
(-), deer home range had significantly less than expected.

APPENDIX III (continued)

Deer and year	Habitat category	Average proportion found on random areas (availability)	Proportion found on deer home range ($\bar{p}$i) (use)	Confidence interval on proportion of availability
2-8 1980	N/A[a]			
2-8 1981	unlogged upland	0.37	0.675	$0.51 \leq 0.37 \leq 0.85$ (+)
	logged upland	0.50	0.175	$0.07 \leq 0.50 \leq 0.29$ (-)
	unlogged riparian	0.10	0.10	--
	logged riparian	0.03	0.05	$-0.02 \leq 0.03 \leq 0.12$
			N = 40	
1-3 1980	unlogged upland		0.64	$0.56 \leq 0.37 \leq 0.72$ (+)
	logged upland		0.15	$0.09 \leq 0.50 \leq 0.21$ (-)
	unlogged riparian		0.19	$0.12 \leq 0.10 \leq 0.26$ (+)
	logged riparian		0.02	---
			N = 17	
1-3 1981	unlogged upland		0.67	$0.58 \leq 0.37 \leq 0.76$ (+)
	logged upland		0.07	$0.02 \leq 0.50 \leq 0.12$ (-)
	unlogged riparian		0.24	$0.15 \leq 0.10 \leq 0.33$ (+)
	logged riparian		0.02	$-0.01 \leq 0.03 \leq 0.05$
			N = 123	
1-11 1980	unlogged upland		0.39	$0.20 \leq 0.37 \leq 0.58$
	logged upland		0.06	$-0.03 \leq 0.50 \leq 0.15$ (-)
	unlogged riparian		0.55	$0.36 \leq 0.10 \leq 0.74$ (+)
	logged riparian		0.0	---
			N = 33	
1-11 1981	unlogged upland		0.46	$0.30 \leq 0.37 \leq 0.62$
	logged upland		0.02	$-0.03 \leq 0.50 \leq 0.07$ (-)
	unlogged riparian		0.52	$0.36 \leq 0.10 \leq 0.68$ (+)
	logged riparian		0.0	---
			N = 48	

[a]χ^2, not significant.

APPENDIX III (continued)

Deer and year	Habitat category	Average proportion found on random areas (availability)	Proportion found on deer home range ($\bar{p}i$) (use)	Confidence interval on proportion of availability
1-2 1980	N/A			
1-2 1981	unlogged upland	0.37	0.80	$0.60 \leq 0.37 \leq 1.0$ (+)
	logged upland	0.50	0.025	$-0.055 \leq 0.50 \leq 0.10$ (-)
	unlogged riparian	0.10	0.15	$-0.03 \leq 0.10 \leq 0.33$
	logged riparian	0.03	0.025	$-0.055 \leq 0.03 \leq 0.10$
			N = 20	
2-1 1980	N/A			
2-1 1981	unlogged upland		0.58	$0.47 \leq 0.37 \leq 0.69$
	logged upland		0.35	$0.24 \leq 0.50 \leq 0.46$ (-)
	unlogged riparian		0.05	$0.0 \leq 0.10 \leq 0.10$
	logged riparian		0.02	$-0.01 \leq 0.03 \leq 0.05$
			N = 94	
1-6 1980	unlogged upland		0.82	$0.71 \leq 0.37 \leq 0.93$ (+)
	logged upland		0.13	$0.03 \leq 0.50 \leq 0.23$ (-)
	unlogged riparian		0.05	$-0.02 \leq 0.10 \leq 0.12$
	logged riparian		0.0	---
			N = 56	
1-6 1981	unlogged upland		0.86	$0.77 \leq 0.37 \leq 0.95$ (+)
	logged upland		0.06	$0.0 \leq 0.50 \leq 0.12$ (-)
	unlogged riparian		0.08	$0.01 \leq 0.10 \leq 0.15$
	logged riparian		0.0	---
			N = 79	
2-11 1980	unlogged upland		0.62	$0.48 \leq 0.37 \leq 0.76$ (+)
	logged upland		0.0	--- (-)
	unlogged riparian		0.38	$0.24 \leq 0.10 \leq 0.52$ (+)
	logged riparian		0.0	---
			N = 63	

APPENDIX III (continued)

Deer and year	Habitat category	Average proportion found on random areas (availability)	Proportion found on deer home range ($\bar{p}i$) (use)	Confidence interval on proportion of availability
1-7	unlogged upland	0.37	0.25	0.17 ≤ 0.37 ≤ 0.33 (-)
1980	logged upland	0.50	0.50	0.41 ≤ 0.50 ≤ 0.59
	unlogged riparian	0.10	0.11	0.05 ≤ 0.10 ≤ 0.17
	logged riparian	0.03	0.14	0.08 ≤ 0.03 ≤ 0.20 (+)
			N = 143	
1-8	unlogged upland		0.01	-0.01 ≤ 0.37 ≤ 0.03 (-)
1981	logged upland		0.77	0.70 ≤ 0.50 ≤ 0.84 (+)
	unlogged riparian		0.01	-0.01 ≤ 0.10 ≤ 0.03 (-)
	logged riparian		0.21	0.14 ≤ 0.03 ≤ 0.28 (+)
			N = 158	
1-12	unlogged upland		0.51	0.43 ≤ 0.37 ≤ 0.59 (+)
1981	logged upland		0.32	0.25 ≤ 0.50 ≤ 0.39 (-)
	unlogged riparian		0.09	0.05 ≤ 0.10 ≤ 0.13
	logged riparian		0.08	0.04 ≤ 0.03 ≤ 0.12 (+)
			N = 207	
1-4	unlogged upland		0.74	0.64 ≤ 0.37 ≤ 0.84 (+)
1981	logged upland		0.15	0.07 ≤ 0.50 ≤ 0.23 (-)
	unlogged riparian		0.11	0.04 ≤ 0.10 ≤ 0.18
	logged riparian		0.0	---
			N = 99	
YEARLINGS				
1-5	unlogged upland		0.04	-0.02 ≤ 0.37 ≤ 0.10 (-)
1981	logged upland		0.67	0.52 ≤ 0.50 ≤ 0.82 (+)
	unlogged riparian		0.06	-0.01 ≤ 0.10 ≤ 0.13
	logged riparian		0.23	0.10 ≤ 0.03 ≤ 0.36 (+)
			N = 51	
2-3	unlogged upland		0.08	0.02 ≤ 0.37 ≤ 0.13 (-)
1981	logged upland		0.66	0.56 ≤ 0.50 ≤ 0.76 (+)
	unlogged riparian		0.04	0.0 ≤ 0.10 ≤ 0.08 (-)
	logged riparian		0.22	0.13 ≤ 0.03 ≤ 0.31 (+)
			N = 106	

APPENDIX III (continued)

Deer and year	Habitat category	Average proportion found on random areas (availability)	Proportion found on deer home range ($\bar{p}i$) (use)	Confidence interval on proportion of availability
2-5	unlogged upland	0.37	0.22	$0.17 \leq 0.37 \leq 0.27$ (-)
1981	logged upland	0.50	0.67	$0.61 \leq 0.50 \leq 0.73$ (+)
	unlogged riparian	0.10	0.06	$0.03 \leq 0.10 \leq 0.09$ (-)
	logged riparian	0.03	0.05	$0.02 \leq 0.03 \leq 0.08$
			N = 339	
2-4	unlogged upland		0.68	$0.58 \leq 0.37 \leq 0.78$ (+)
1981	logged upland		0.24	$0.15 \leq 0.50 \leq 0.33$ (-)
	unlogged riparian		0.08	$0.02 \leq 0.10 \leq 0.14$
	logged riparian		0.0	---
			N = 108	
2-2	unlogged upland		0.73	$0.65 \leq 0.37 \leq 0.81$ (+)
1981	logged upland		0.05	$0.01 \leq 0.50 \leq 0.09$ (-)
	unlogged riparian		0.22	$0.15 \leq 0.10 \leq 0.31$ (+)
	logged riparian		0.0	---
			N = 151	

APPENDIX IV

HABITAT TYPE MOSAICS ON DEER RANGES

Deer	Mapping unit[a]	Area (acres)	Habitat Type Mosaic H.T.	% coverage
ADULTS				
2-10	A	69	Abla/Clun-Xete	100
	B	64	Abla/Clun-Xete	60
			Abla/Clun-Clun	30
			Abla/Libo-Xete	10
	C	30	Abla/Clun-Clun	100
	D	8	water, potholes	
2-8	A	13	Abla/Xete-Vagl	100
	A, logged	6	same	100
	B	27	Abla/Mefe	95
			Abla/Clun-Mefe	5
	B, logged	47	Abla/Mefe	95
			Abla/Clun-Mefe	5
	C	8	water	
1-11	A	10	Psme/Vaca	5
			Abla/Clun-Vaca	95
	B	4	Psme/Vaca	70
			Picea/Clun-Clun	20
			Picea/Eqar	10
	C	22	Abla/Clun-Vaca	100
	F	5	Picea/Clun-Vaca	100
	G	32	wet meadow, pothole	
	H	3	water	
1-2	A	30	Psme/Syal-Caru	5
			Abla/Clun-Clun	15
			Abla/Clun-Vaca	80
	B	4	Abgr/Clun-Clun	5
			Abla/Clun-Clun	95
	C	4	water	

[a]Mapping units, based on differences in H.T., topographic feature, and cover-successional types, on file.

APPENDIX IV (continued)

Deer	Mapping unit	Area (acres)	Habitat Type Mosaic H.T.	% coverage
1-7	A	51	Abgr/Clun-Xete	85
			Thpl/Clun-Mefe	15
	B	18	Abgr/Clun-Xete	100
	C	107	Thpl/Clun-Mefe	100
	D	38	Picea/Eqar	100
2-1	A	12	Abla/Vaca	90
			Abla/Clun-Mefe	2
			Abla/Libo-Vasc	5
			Abla/Clun-Vaca	3
	B	18	Abla/Vaca	80
			Abla/Xete-Vasc	20
	C	19	Abla/Xete-Vasc	80
			Abla/Xete-Vagl	10
			Abla/Libo-Vasc	2
			Abla/Vaca	2
			Abla/Clun-Vaca	2
			Picea/Clun-Clun	4
	D	28	Abla/Xete-Vagl	90
			Abla/Clun-Mefe	5
			Abla/Clun-Clun	5
	E	18	Abla/Libo-Xete	50
			Abla/Xete-Vasc	20
			Abla/Clun-Clun	18
			Abla/Clun-Xete	10
			Abla/Vaca	2
	F	20	Abla/Xete-Vagl	80
			Abla/Xete-Vasc	20
	G	10	Abla/Clun-Xete	100
	H	14	Abla/Vaca	90
			Abla/Clun-Vaca	10
	J	33	Abla/Libo-Vasc	60
			Abla/Xete-Vasc	20
			Abla/Vaca	10
			Abla/Libo-Xete	10
	K	7	water	

APPENDIX IV (continued)

Deer	Mapping unit	Area (acres)	Habitat Type Mosaic H.T.	% coverage
2-11	A	26	Abla/Xete-Vagl	80
			Psme/Syal-Caru	10
			Picea/Clun-Clun	10
	B	37	Picea/Clun-Clun	15
			Picea/Eqar	5
			Abla/Clun-Xete	75
			Abla/Clun-Mefe	5
	C	23	Picea/Clun-Clun	5
			Picea/Eqar	5
			Abla/Clun-Arnu	5
			Abla/Xete/Vagl	10
			Abla/Clun-Xete	70
			Abla/Clun-Mefe	5
	D	4	water	
1-6	A	35	Abla/Xete-Vagl	90
			Abla/Vaca	5
			Psme/Syal-Caru	5
	B	32	Abla/Libo-Xete	20
			Abla/Xete-Vagl	60
			Abla/Vaca	20
	C	17	Abla/Vaca	5
			Abla/Xete-Vasc	30
			Abla/Xete-Vagl	65
	D	21	Abla/Xete-Vagl	80
			Abla/Clun-Xete	15
			Abla/Libo-Xete	5
	E	24	Abla/Libo-Xete	5
			Psme/Syal-Caru	1
			Abla/Vaca	5
			Abla/Xete-Vagl	90
	F	4	Picea/Eqar	100
	G	3	water	
1-8	A	29	Thpl/Clun-Arnu	70
			Thpl/Opho	10
			Picea/Eqar	20
	B	134	Thpl/Clun-Clun	100
	C	58	Abla/Clun-Arnu	100
	D	17	Picea/Eqar	100
	E	2	Abla/Clun-Arnu	100

APPENDIX IV (continued)

Deer	Mapping unit	Area (acres)	Habitat Type Mosaic H.T.	% coverage
1-12	A	15	Abla/Clun-Clun	100
	B	124	Abla/Clun-Xete	100
	C	23	Abla/Clun-Xete	100
	D	20	Picea/Eqar	100
	E	27	Picea/Clun-Clun	100
	F	19	Abla/Vaca	50
			Abla/Libo-Xete	30
			Abla/Xete-Vagl	10
			Abla/Xete-Vasc	5
			Abla/Clun-Clun	5
	G	9	Picea/Clun-Vaca	100
	H	21	Picea/Clun-Clun	100
	I	26	Abla/Clun-Clun	100
	J	32	Abla/Vaca	50
			Abla/Libo-Xete	30
			Abla/Xete-Vagl	10
			Abla/Xete-Vasc	5
			Abla/Clun-Clun	5
	K	9	avalanche chute	
1-4	A	12	Abla/Alsi	100
	B	56	Abla/Alsi	85
			Abla/Libo-Xete	5
			Abla/Clun-Clun	5
			Abla/Clun-Xete	5
	C	5	Abla/Vaca	20
			Abla/Libo-Xete	10
			Abla/Xete-Vagl	70
	D	19	Abla/Vaca	15
			Abla/Xete-Vasc	85
	E	15	Picea/Eqar	100
	F	4	Abla/Vaca	20
			Abla/Xete-Vagl	40
			Abla/Xete-Vasc	40
	G	23	Abla/Vaca	20
			Abla/Xete-Vagl	40
			Abla/Xete-Vasc	40
	H	9	Abla/Vaca	20
			Abla/Xete-Vagl	40
			Abla/Xete-Vasc	40
	I	13	Abla/Mefe	100

APPENDIX IV (continued)

Deer	Mapping unit	Area (acres)	Habitat Type Mosaic H.T.	% coverage
YEARLINGS				
2-2	A	109	Abla/Vaca	60
			Psme/Vaca	30
			Psme/Vagl-Xete	5
			Abla/Xete-Vagl	5
	B	19	Abla/Libo-Xete	50
			Abla/Vaca	50
	C	15	Abla/Libo-Xete	100
	D	18	Abla/Clun-Clun	50
			Picea/Clun-Clun	50
	E	5	Psme/Vaca	100
	F	42	Abla/Vaca	40
			Abla/Libo-Xete	30
			Abla/Xete-Vagl	30
	G	12	Abla/Vaca	100
2-3	A	55	Abla/Clun-Arnu	100
	B	25	Abla/Clun-Xete	100
	C	10	Abla/Clun-Arnu	100
	D	42	water	
	E	5	Abla/Clun-Arnu	100
	F	1	Picea/Eqar	100
	G	13	Abla/Clun-Arnu	100
1-5	A	50	Abla/Clun-Xete	100
	B	30	Picea/Eqar	25
			Picea/Clun-Clun	25
			Abla/Clun-Arnu	25
			Abla/Clun-Xete	25
	C	4	Abla/Clun-Mefe	70
			Abla/Clun-Xete	30
2-4	A	10	Abla/Alsi	100
	B	36	Abla/Alsi	85
			Abla/Libo-Xete	5
			Abla/Clun-Clun	5
			Abla/Clun-Xete	5
	C	2	Abla/Vaca	20
			Abla/Libo-Xete	10
			Abla/Xete-Vagl	70

APPENDIX IV (continued)

Deer	Mapping unit	Area (acres)	Habitat Type Mosaic H.T.	% coverage
2-4 (continued)				
	D	4	Abla/Vaca	15
			Abla/Xete-Vasc	85
	E	9	Picea/Eqar	100
	G	27	Abla/Vaca	20
			Abla/Xete-Vagl	40
			Abla/Xete-Vasc	40
	H	2	Abla/Xete-Vagl	50
			Abla/Xete-Vasc	50
	I	17	Abla/Xete-Vagl	70
			Abla/Vaca	30
	J	8	Abla/Xete-Vagl	40
			Abla-Xete-Vasc	60
	J, logged	2	same	
	K	1	Picea/Clun-Clun	99
			Abla/Clun-Xete	1
	L	3	Abla/Clun-Mefe	20
			Abla/Mefe	80
	M	6	Abla/Clun-Xete	100
	M, logged	2	same	
	N	4	Abla/Xete-Vagl	50
			Abla/Xete-Vasc	50
	N, logged	2	same	
	O	3	Abla/Xete-Vagl	50
			Abla/Xete-Vasc	50
	O, logged	4	same	
	P	2	Abla/Xete-Vasc	70
			Abla/Clun-Mefe	10
			Abla/Xete-Vagl	20
	Q	15	Abla/Mefe	100

APPENDIX V

HABITAT TYPE MOSAICS ON RANDOM AREAS

Random area	Mapping unit	Area (acres)	Habitat Type Mosaic H.T.	% coverage
1	A	36	Abla/Clun-Vaca	20
			Picea/Vaca	60
			Abgr/Clun-Clun	20
	B	4	Abgr/Clun-Arnu	100
	C	7	Abgr/Clun-Arnu	100
	D	40	Abgr/Clun-Clun	100
	E	15	Abla/Clun-Xete	100
2	A	41	Picea/Clun-Vaca	90
			Abgr/Clun-Clun	10
	B	22	Abla/Clun-Vaca	100
	C	36	Abla/Clun-Vaca	50
			Picea/Clun-Vaca	50
	D	3	Abgr/Clun-Arnu	100
3	A	17	water	
	B	20	Abla/Clun-Vaca	70
			Thpl/Clun-Clun	30
	C	22	Abla/Clun-Vaca	100
	D	20	Abla/Clun-Vaca	100
	E	12	Abla/Clun-Vaca	100
	F	9	Abla/Clun-Clun	100
4	A	13	Picea/Clun-Vaca	80
			Aspen wet spots	20
	B	92	Picea/Clun-Vaca	80
			Aspen	20
5	A	9	Abla/Clun-Vaca	100
	B	15	Abla/Clun-Vaca	95
			Abla/Clun-Arnu	5
	C	73	Abla/Clun-Vaca	100
6	A	43	Abla/Clun-Vaca	80
			Picea/Clun-Clun	10
			Abgr/Clun-Clun	10

APPENDIX V (continued)

Random area	Mapping unit	Area (acres)	Habitat Type Mosaic H.T.	% coverage
6 (continued)				
	B	62	Abla/Clun-Vaca	80
			Picea/Clun-Clun	20
	C	11	Picea/Eqar	100
7	A	58	Abla/Mefe	40
			Abla/Libo-Xete	40
			Abla/Vaca	20
	B	8	Picea/Clun-Clun	100
	C	22	Abla/Vaca	35
			Abla/Libo-Xete	65
	D	17	Abla/Libo-Xete	90
			Abla/Vaca	10
	E	2	water	
8	A	55	Abla/Clun-Vaca	100
	B	33	Abla/Clun-Vaca	95
			Cottonwood-Aspen	5
	C	34	Abla/Clun-Vaca	100
	D	11	Abgr/Clun-Xete	35
			Abla/Clun-Vaca	60
			Abla/Clun-Mefe	5
	E	1	water	
9	A	25	Picea/Clun-Vaca	100
	B	81	Abla/Clun-Vaca	25
			Picea/Clun-Vaca	50
			Psme/Vaca	25
	C	6	Riparian	
10	A	27	Abla/Clun-Vaca	100
	B	75	Abla/Clun-Vaca	100
	C	15	Riparian	
11	A	26	Thpl/Clun-Arnu	100
	B	86	Thpl/Clun-Arnu	90
			Picea/Eqar	10
	C	6	Picea/Eqar	100

APPENDIX V (continued)

Random area	Mapping unit	Area (acres)	Habitat Type Mosaic H.T.	% coverage
12	A	37	Abla/Clun-Xete	60
			Abgr/Clun-Xete	40
			Abla/Mefe	trace
	B	6	Abla/Vaca	100
	C	6	Abla/Libo-Xete	100
	D	70	Riparian	
13	A	19	Abla/Clun-Mefe	60
			Abla/Mefe	40
	B	8	Abla/Xete-Vagl	80
			Abla/Libo-Xete	20
	C	6	Picea/Clun-Clun	100
	D	14	Abla/Xete-Vagl	100
	E	32	Abla/Xete-Vagl	90
			Abla/Libo-Xete	10
	F	5	Abla/Xete-Vagl	95
			Psme/Syal-Caru	5
	G	19	Abla/Xete-Vagl	90
			Abla/Libo-Xete	5
			Abla/Vaca	3
			Abla/Xete-Vasc	2
14	A	16	Abla/Clun-Vaca	100
	B	54	Abgr/Clun-Clun	50
			Abgr/Clun-Xete	50
	C	40	Abgr/Clun-Clun	100
	D	3	Abgr/Clun-Clun	100
	E	3	Picea/Clun-Clun	100
	F	4	Picea/Eqar	100
15	A	12	Thpl/Clun-Arnu	100
	B	4	Picea/Eqar	100
	C	28	Thpl/Clun-Mefe	100
	D	9	Thpl/Clun-Mefe	30
			Abla/Clun-Vaca	70
	E	22	Abla/Clun-Vaca	100
	F	10	Abla/Clun-Vaca	90
			Thpl/Clun-Mefe	10
	G	9	water	
	H	9	pothole	